Final report

OWMC
Ontario
Waste Management
Corporation

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ONTARIO RESEARCH FOUNDATION

SITE SELECTION PROCESS,
PHASE 4A: SELECTION OF A PREFERRED SITE(S) -
Atmospheric Considerations

for

ONTARIO WASTE MANAGEMENT CORPORATION

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October 28, 1985

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October 28, 1985

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Attention: Mr. J.G. Micak
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Dear Sirs,

We are pleased to submit our final report on Phase 4A of the OWMC project, entitled "Site Selection Process - Phase 4A: Selection of Preferred Site - Atmospheric Considerations". This report documents the work activities undertaken during this phase of the programme, and includes our preference of siting options based on a detailed comparative evaluation of air quality and atmospheric dispersion factors.

We appreciate the opportunity to have undertaken this work for you.

Yours truly,

C Baynes

Colin Baynes
Special Consultant
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EXECUTIVE SUMMARY

PURPOSE OF THE REPORT

The main purpose of this report is to provide a detailed comparative evaluation of the Ontario Waste Management Corporation's (OWMC's) candidate siting options for a proposed industrial waste management facility, based on considerations of air quality and atmospheric dispersion. The report documents the analyses undertaken to establish an order of preference of the siting options, from the standpoint of atmospheric conditions.

SCOPE AND METHOD

Several site selection factors were selected as the basis for the comparison of siting options. These were selected and analyzed in a manner consistent with OWMC's stated objectives of minimizing the risks to human health and environmental impacts of the proposed facility through the site selection process. One group of factors included consideration of potential <u>risks</u> to human health through direct inhalation of emissions, consumption of crops and livestock, and ingestion of cistern and pond water. The second factor grouping was concerned with more general air quality <u>impacts</u>, including atmospheric dispersion conditions. The factors were subdivided into a number of indicators designed to characterize the essential differences between sites.

Mathematical dispersion modelling techniques were used in combination with data on population, crops, livestock, and cistern and pond usage around each site, to estimate exposure indices for each siting option. These were used as measures of relative risks to the population due to atmospheric emissions from the facility. As well, an assessment was made of the relative significance of any local restraints to dispersion, the existing air quality and the incremental effect of the facility on air quality.

The siting options were assigned a suitability level under each indicator on a scale of -1.0 (least risk or impact) to -5.0 (most risk or impact). Each indicator was assigned a weight based on its relative significance, using a scale from 1 (least significant) to 5 (most significant).

This report also documents a series of sensitivity analyses which were conducted to test the effects on the order of preference of siting options of possible local variations in dispersion climatologies, alternative acute exposure indices, and an alternative indicator weighting scheme.

An analysis was carried out as part of the selection of preferred locations for the physical/chemical treatment plant for three partially integrated siting options.

PREMISES AND POSTULATES

This study was based on three fundamental premises:

- the study was restricted to the candidate sites previously selected by OWMC,

- emissions and atmospheric dispersion estimates were based on the current reference design of the proposed facility.

In addition, it was necessary to adopt the following assumptions or postulates in the course of the study:

- mathematical dispersion modelling was widely used to predict ambient concentrations of emissions. A number of simplifying assumptions and approximations are inherent in the models used. Nevertheless, they are believed to provide best estimates of actual conditions,

- existing air quality and projected impacts due to the proposed OWMC facility are expressed in terms of concentrations of four common air pollutants. It is assumed that these can be regarded as surrogates for other common air pollutants which would be emitted by the facility,

- a number of assumptions are made regarding emissions from the various components of the OWMC facility, based on the current reference design,

- in the process of ranking the site options, various postulates were adopted regarding the relative significance of the site selection factors and indicators. As well, some decisions on the relative suitability of the siting options have been made subjectively. In some cases, alternative interpretations or assumptions could significantly alter the order of preference of the siting options. The effects of these alternatives on the order of preference of the options have been tested in a series of sensitivity analyses.

STATUS OF DATA

The major sources of data are given below:

- topographic maps
- meteorological and climatological (Atmospheric Environment Service)
- emissions (based on published papers and reports and the reference design of the proposed facility)
- existing air quality (Ontario Ministry of the Environment and ORF, 1984)
- distributions of population, crops, livestock, cisterns and ponds around the candidate sites (other OWMC consultants)
- results of a generic risk assessment of emissions from the OWMC facility (Environ, 1985).

Topographic information was used to assess the potential for local variations in dispersion climatology and for concentration of any accidental releases of a heavy vapour from the facility. The assessment was based on professional judgement; more detailed quantitative considerations are expected to form part of the site-specific studies of the preferred siting option.

Meteorological and climatological data from three stations (St. Catharines, Toronto and Mount Hope) were used in the dispersion modelling

to represent conditions at the candidate sites. These data are considered to provide the best resolution available, although local conditions at some candidate sites may not be fully reflected in the data. Where there was significant doubt, a sensitivity analysis was conducted to determine the likely effect of such local conditions on the order of preference of the siting options. Again, a more detailed assessment of local climatology is expected in future site-specific studies of the preferred option.

The emission data used in this study are intended to represent, in a conservative manner, long-term average conditions. They are based on the current reference design for the OWMC facility and, as such, are subject to change as refinements to the design are introduced.

The Ontario Ministry's emission inventory, and the description of existing air quality based on it, are subject to error due to various omissions and approximations. Further details are given in an earlier report (ORF, 1984).

Some basic data for this study and the results of the generic risk assessment were provided by other OWMC consultants. Any limitations of these data are addressed in their respective reports on this phase of the site selection process. One limitation of significance to this study concerns sensitive crop and livestock data. In the absence of more specific information, the total weight of edible crops and livestock produced around the candidate sites has been used in estimating the relative health risks associated with the human consumption of these products. It is anticipated that further refinement of the data will improve the risk estimates, although this is not expected to affect the conclusions of this report.

MAIN FINDINGS

The major findings of this study are as follows:

- Considering air quality and atmospheric dispersion conditions, no grounds could be found for rejecting any of the siting options as basically unacceptable.

- The analysis of the partially integrated siting options indicated that the preferred locations for the physical/chemical treatment plant would be at LF4N, in the case of the siting options in Milton. No clear difference was indicated between the options at Niagara Falls.

- The numerical analysis of risk factors gave the following order of preference of the six siting options studied in the detailed comparative evaluation: LF3C, LF9C and LF1E, LF1E/PI27E, LF4N/PI1N, LF4N/PI13N.

- The numerical analysis of impact factors gave the following order of preference: LF3C and LF9C, LF1E, LF4N/PI13N, LF4N/PI1N, LF1E/PI27E.

- The sensitivity analysis of the data did not suggest any major changes in the overall order of preference of the siting options, although the analysis of alternative acute exposure indices showed a greater relative preference for LFIE, at the expense of LF9C.

CONCLUSIONS AND RECOMMENDATIONS

A number of conclusions and recommendations resulted from this study:

- All siting options are considered acceptable from the standpoint of air quality and atmospheric dispersion.

- The preferred location of the physical/chemical treatment plant in the partially integrated siting options at Milton is at LF4N. However, there is no clear preference regarding the options at Niagara Falls from an air quality and atmospheric dispersion perspective.

- The detailed comparative evaluation of six candidate siting options was conducted, using a numerical ranking scheme. From the analysis it is concluded that, in order to minimize risk to public health due to air emissions, LF3C in West Lincoln is the preferred siting option. LF9C, also in West Lincoln and LF1E, in Niagara Falls, rank equally as the second most preferred siting options. Considering more general air quality impacts, LF3C and LF9C are equally the most preferred options. Overall, the preference is for the West Lincoln sites.

- The sensitivity analyses conducted in this study confirmed the overall preference for the West Lincoln sites.

- It is recommended that site-specific dispersion data be collected at the preferred site and, based on these data, further detailed dispersion modelling be carried out. An on-site air quality monitoring programme is also recommended, in order to validate the data used in the present study.

- The implications of any significant design changes on the results of this study should be reviewed.

- Although the overall preference for options LF3C and LF9C is not expected to be affected, further work is recommended to refine the data on agricultural products which would be most significant in transmitting toxic air emissions to humans. This will allow the sensitive crop and livestock exposure indices calculated in this study to be refined and more accurately reflect comparative population risks between the siting options.

1. INTRODUCTION

1.1 PURPOSE AND SCOPE

The main purpose of this report is to provide a detailed comparative evaluation of Ontario Waste Management Corporation's (OWMC's) candidate siting options for a proposed industrial waste management facility, based on considerations of air quality and atmospheric dispersion conditions.

The work described herein encompasses the selection of factors and indicators used to characterize the options, the analysis of site-specific data relating to the selected indicators, the ranking of the options under each indicator, the assignment of weights to the indicators and, finally, the aggregation of the results to establish an order of preference of the siting options from an air quality perspective. The report also addresses the selection of the candidate siting options from among the seven* candidate sites (some siting options involve two sites) and the sensitivity of the order of preference to certain changes in the analysis.

Results of this study are used in the overall evaluation of this phase of the site selection process (Dillon, 1985).

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*Note: Although data were collected and analyzed for eight candidate sites, the comparative evaluation was performed on siting options involving seven sites. The eighth (LF-2N in Mississauga) was dropped as a candidate site in May, 1985 for reasons unrelated to air quality and atmospheric dispersion (Dillon, 1985).

In the course of this phase of site selection, a variety of data were obtained from other OWMC consultants for use in the analysis. As well, data were provided to other consultants for use in their analyses. Table 1.1 summarizes these exchanges.

1.2 PREVIOUS WORK

The Phase 3 site selection process conducted by Ontario Waste Management Corporation previously included the selection of candidate areas, site areas, potential sites and candidate sites. The Ontario Research Foundation (ORF) contributed to the identification of candidate areas by locating areas in the Golden Horseshoe region which, due to their geographical location, would be expected to experience relatively poor conditions of atmospheric dispersion, possibly leading to relatively frequent episodes of poor air quality. These areas were excluded from consideration in the selection of OWMC candidate areas. Because of this early influence in the site selection process, air quality and atmospheric dispersion were not considered in the selection of site areas from within the candidate areas, nor in the subsequent selection of potential sites from within the site areas. This approach is appropriate considering the scale at which air quality phenomena occur, and the limited spatial resolution of relevant parameters which could be developed from data available at the time.

In the most recent study in Phase 3B (ORF, 1984), ORF evaluated the existing air quality across the candidate areas by consolidating available information on meteorology, climatology, topography, atmospheric emissions and ambient air quality. This study also included a preliminary evaluation of fourteen potential incinerator sites, based on air quality considerations and a general review of local potential receptors. The results of this evaluation were included in the overall site selection process and were an integral part of the data used to select the original eight candidate sites (Dillon, 1984). The locations of the sites are shown in Figure 1.1.

TABLE 1.1

Data Exchange With Other OWMC Consultants
During Phase 4A Site Selection

Data Description	Received From	Provided To
Population distribution around each site (present)	IER	
Population distribution around each site (future)	Leon Kentridge Assoc.	
Community facility distribution around each site	IER	
Crops and livestock distribution around each site (present and future)	Ecologistics	
Crop and livestock exposure indices for each site (economic exposure indices)		Ecologistics
Cistern and pond distribution around each site	Gartner Lee Assoc.	
Results of generic risk assessment	Environ Corp.	
Results of dispersion analyses of maximum ambient concentrations due to routine and accidental emissions.		Environ Corp.

FIGURE 1.1: LOCATIONS OF THE CANDIDATE SITES

1.3 FACILITY CHARACTERISTICS

The proposed OWMC facility will treat both organic and inorganic industrial wastes. Organic wastes will be destroyed thermally in a rotary kiln incinerator, and the inorganic wastes rendered stable and non-toxic by physical/chemical treatment processes. Residues of the incinerator flue gas treatment system and the physical/chemical treatment plant will be solidified and disposed of in an engineered landfill (Monenco, 1985).

One, and ultimately two, 30 000 t/a capacity rotary kiln incinerators with secondary combustion will thermally destroy the organic wastes. Off-gases will be cleaned by a flue gas treatment system. It is expected that acid gases will be controlled by means of a wet scrubbing system and particulate matter by an electrostatic precipitator. Residual contaminants in the flue gas will then be discharged through a tall stack. In this evaluation, the reference stack design is considered, having a height of 60 m, with a flue gas exit temperature of 130^{o}C, and an exit velocity of 20 m/s. The diameter of each flue is 1.3 m (one flue per incinerator, but housed within a common shell, with a combined effective diameter of 1.84 m).

Potential air emissions from the incinerator stack include the following pollutants: acid gases (such as sulphur dioxide, nitrogen oxides and hydrogen chloride), trace metals, various organic compounds, and particulate matter. Present uncertainties regarding the waste streams to be handled, and the detailed design of the control equipment, make it difficult to derive emission rates for all of the above mentioned pollutants. For the present purpose, emission estimates for four common or "criteria" pollutants were used for comparison with existing air quality. These are sulphur dioxide (SO_2), nitrogen oxides (NO_x), total suspended particulates (TSP), and total hydrocarbons (THC).

Emissions other than those from the incinerator stack, i.e. fugitive emissions released at or near ground level, can be expected from other components of the facility. These fugitive emissions will be

controlled. However, residual hydrocarbon emissions can be expected from the following process components: liquid organic storage (i.e. from the truck load-out area and the tank farm), liquid organic distribution, and the physical/chemical treatment plant. Fugitive emissions of particulate matter are expected from the following activities: physical/chemical treatment, incinerator ash handling, landfill soil removal and replacement, and vehicle traffic.

1.4 GENERAL APPROACH

Factors which involve potential risks to human health and environmental impacts as a result of atmospheric emissions have been chosen for use in this detailed comparative analysis. These factors were sub-divided into a number of indicators designed to characterize the essential differences between sites. The selection and treatment of factors were designed to be consistent with OWMC's stated goals for the site selection process, i.e., to minimize risks to human health and environmental impacts (the third goal, to minimize costs, is beyond the scope of this study).

Six factors were considered, in two groups. The first group is related to the potential <u>risks</u> to human health from atmospheric emissions, whether by direct inhalation of emissions, consumption of crops and livestock contaminated by emissions, or ingestion of contaminated cistern and pond water. The second group is concerned with general air quality <u>impacts</u>, including atmospheric dispersion conditions.

Mathematical dispersion modelling techniques were used in combination with data on population, crops, livestock, and cistern and pond water usage around the candidate sites. The analysis resulted in exposure indices which express, in relative terms, the population risks due to atmospheric emissions at the candidate sites.

An assessment of any restraints to dispersion, existing air quality and the incremental effect of the OWMC facility was also undertaken for each siting option, again with the aid of mathematical dispersion modelling.

The analysis of the site specific data under each indicator enabled the siting options to be assigned a suitability level ranging from -1.0 (least risk or impact) to -5.0 (most risk or impact). Each indicator was assigned a weighting on a scale of 1 (least significant) to 5 (most significant).

For indicators within the factor grouping concerned with the potential risks to human health, the weightings were based on three main criteria:

a) severity of the risk
b) frequency and duration of the associated effect, and
c) the potential for remedial action or mitigation

Information on the severity of risks was drawn from the results of a generic risk assessment of the potential effects of OWMC facility emissions on human health (Environ, 1985).

For indicators within the factor grouping concerned with air quality impacts, the weightings were based on the following:

a) likelihood of an effect
b) severity of the associated effect, and
c) the potential for remedial action or mitigation

The order of preference of the siting options under each factor or factor grouping was established by summing the weighted suitability levels assigned to the siting options over all indicators within the factor or factor grouping.

1.5 SUMMARY OF STUDY LIMITATIONS

Every effort has been made to make the best use of the available data and to ensure the accuracy of the analysis, consistent with the site selection process. However, there are a number of limitations inherent in the data and analyses. The more significant limitations are identified below.

The study makes extensive use of mathematical dispersion modelling. The models, although widely accepted and based on theoretical and empirical evidence, give only imperfect representations of the real physical processes involved. A number of simplifying assumptions and approximations are built into the models. Furthermore, they are also limited by the representativeness of the meteorological and emissions data, which are necessary inputs to the models. Specific details of the data used in this study are discussed later in this report.

A number of assumptions have been made regarding emissions from the proposed OWMC facility and the design of the incinerator stack. These are based on the reference design at the time this work was undertaken and are subject to change as the detailed design of the facility progresses. As well, existing ambient air quality at the candidate sites, and the projected impacts of emissions from the proposed facility, are expressed in terms of concentrations of four common air pollutants (sulphur dioxide, nitrogen oxides, total suspended particulates and total hydrocarbons). These are the pollutants for which data on existing levels are available for the candidate sites. It is assumed that these can be considered as surrogates for other common air pollutants emitted by the OWMC facility.

Exposure indices were calculated for consumption of crops and livestock based on the total weight of edible agricultural products produced per annum around each site. These values were used in the absence of more specific indicators of the relative health risks due to consumption of those sensitive crops and livestock which may be exposed to atmospheric emissions and would be significant transmitters of these emissions to humans.

Finally, it should be noted that, in the process of ranking the site options and weighting the various indicators, some decisions have been made subjectively, based on professional judgement. However, where there was significant doubt surrounding such decisions, sensitivity analyses have been conducted to test the effects of alternative interpretations on the order of preference of the siting options.

Notwithstanding the limitations identified, the analysis which was undertaken was considered appropriate for the purpose of comparing siting options.

2. SITE SELECTION FACTORS

2.1 INTRODUCTION

The purpose of the site selection factors is to identify the relative risks and impacts of an industrial waste management facility associated with the various siting options. A generic risk assessment has been undertaken on behalf of OWMC (Environ, 1985), which identifies and studies the potential effects on human health associated with the pathways of emissions into the environment. The airborne pathways have been reflected in the choice of risk factors used in this report. Other impact factors are concerned with more general air quality and atmospheric dispersion considerations.

2.2 RISK FACTORS

The OWMC facility will be designed and operated well within the Ontario standards and guidelines applicable to atmospheric emissions. Such strict controls on emissions will minimize the risk to any one individual exposed via any of the airborne pathways from the facility into the environment. In addition, the broader risk to the population can be minimized through site selection, for example, by choosing a site which has a relatively small population in its vicinity.

Routine airborne emissions from the OWMC facility can be divided into:

a) the incinerator stack emissions, which will be released from

a well-defined point, at least 60 m above ground level, and

b) fugitive emissions, released at or near ground level from a wide variety of locations. These will include small losses of volatile organic compounds from the waste unloading and storage areas and suspended particulate matter resulting from landfilling activities. Extensive engineering features will be included to control and reduce fugitive emissions. However, facility components (incinerator, physical/chemical treatment plant and landfill) can be expected to have some emissions of this type.

In addition to these emissions, upset or accidental emissions may occur from time to time, from both the incinerator stack and from other low elevation points around the plant. In general, the continuous emissions represent potential chronic health effects and the upset or accidental emissions represent potential acute health effects.

Once released to the atmosphere, the emissions will be transported downwind and dispersed, depending on wind and weather conditions. The significant potential pathways to humans (Environ, 1985) are:

a) directly, through inhalation of the dispersed emissions

b) indirectly, through uptake of the emissions by crops and livestock and subsequent consumption of these by humans

c) indirectly, through the removal of emissions from the atmosphere by precipitation which is collected in cisterns and ponds and used as potable water.

These are illustrated in Figure 2.1. Chronic health effects are associated with all three pathways, while significant acute effects could only result from direct inhalation.

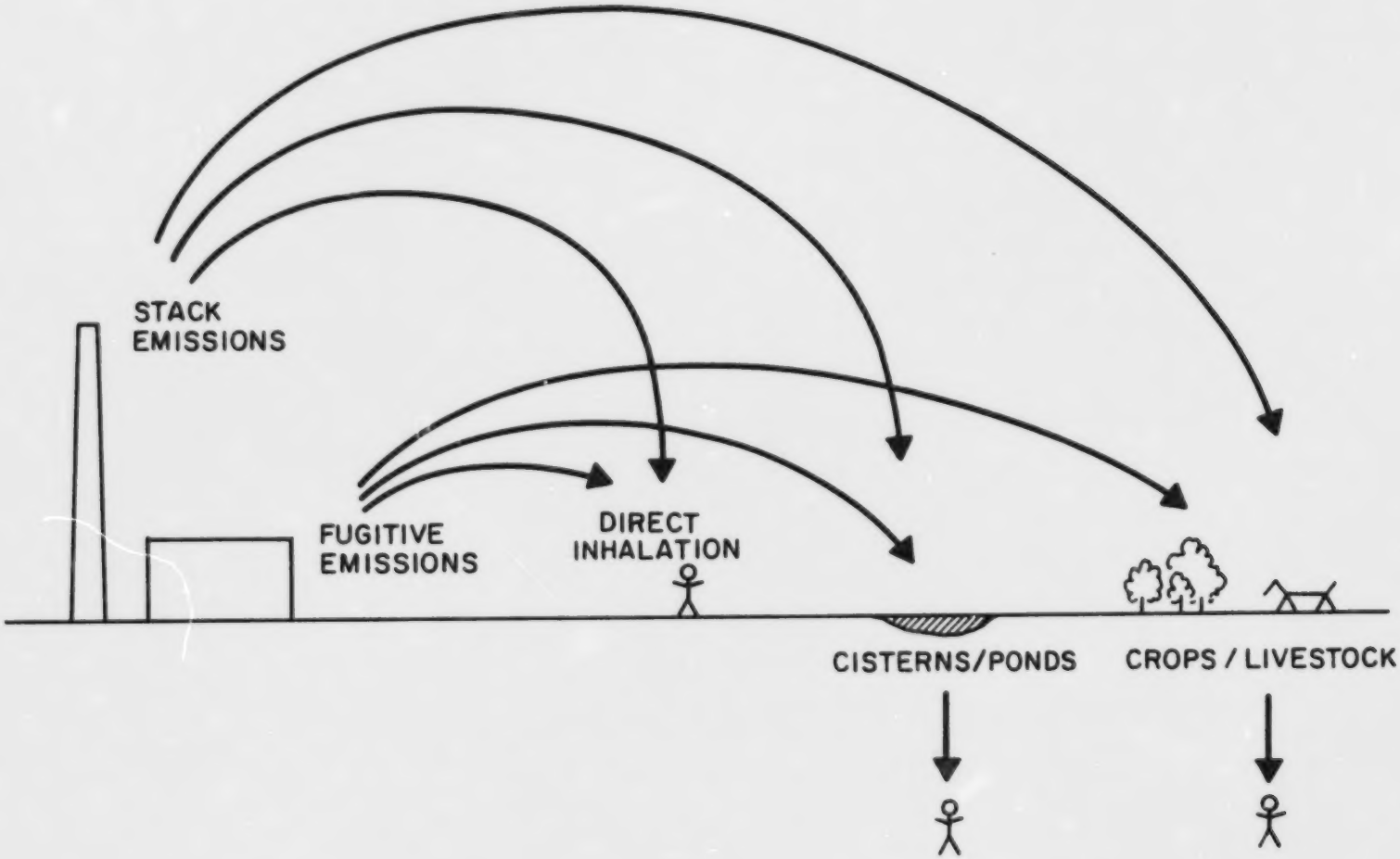


FIGURE 2.1: Significant Potential Air Emissions Pathways to Humans

The factors used in this study address both chronic and acute human health risks and the three major pathways previously identified. Thus, the four factors are:

1. Chronic risks from direct inhalation of emissions (due to routine emissions)

2. Acute risks from direct inhalation of emissions (due to upset emissions)

3. Chronic risks from ingestion of cistern and pond water (due to routine emissions)

4. Chronic risks from consumption of crops and livestock (due to routine emissions)

Within each factor, indicators have been selected which describe the different site characteristics at an appropriate level of detail. As previously noted, the risk to the general population, or population risk, can be minimized through site selection. This is achieved either by minimizing the number of people potentially exposed, directly or indirectly, and/or by minimizing the level of exposure to the emissions. For the direct inhalation pathways, the appropriate indicators reflect the population exposed in the vicinity of the facility, taking into account the relative exposure levels due to dispersion of emissions. For the indirect pathways, the appropriate indicators are the quantities of water, and sensitive crops or livestock which may transmit emissions to humans, again taking relative exposure levels into account.

Exposure indices have been developed, based on these concepts, and are the primary risk indicators used in the comparison of siting options. Details of the derivation of these indices are given in Chapter 3 of this report.

Two additional indicators are used when considering acute risks from direct inhalation of emissions. The first is concerned with any topographic features on or near the site which may cause concentration of an accidental release of a heavy vapour. This may occur where there are significant slopes and depressions in the terrain. Secondly, in the case of upset or accidental emissions, additional risks could be derived from temporary concentrations of sensitive populations in the site vicinity. Therefore, proximity of sites to schools, hospitals and other community facilities has also been used as an indicator.

Table 2.1 summarizes the factors and indicators related to the human health risk from atmospheric emissions. Appendix A contains a summary sheet for each indicator, providing the definition, rationale and significance of the indicator, as well as sources of information, study area, and the assumptions and limitations used in the analysis of each site.

2.3. IMPACT FACTORS

Although the human health risks associated with atmospheric emissions are of primary concern, other potential effects of air pollution are well known. These include adverse effects on animal life, damage to vegetation, degradation of building materials, nuisance, loss of enjoyment of property, and loss of visibility. Conditions could be such that an industrial facility with excessively high emissions, or one which is located in an area of poor air quality, may be subject to regulatory controls on its emissions and operations.

Site selection can be used to minimize these impacts and to avoid undue constraints on facility operations. Thus, the existing levels of air quality, and the expected increment caused by emissions from the OWMC facility are useful considerations in site-selection. In this study, they are combined under one air quality impact factor. In addition, local topographic and climatological conditions may represent a restraint to

TABLE 2.1: Summary of Risk Factors and Indicators

Factor	Indicator
R1. Risks from direct inhalation of emissions - chronic	1. Relative population exposure - incinerator stack emissions
	2. Relative population exposure - fugitive emissions
	3. Relative future population exposure - incinerator stack emissions
	4. Relative future population exposure - fugitive emissions
R2. Risks from direct inhalation of emissions - acute	1. Topographic features on or around site
	2. Relative population exposure - upset emissions from incinerator stack
	3. Relative population exposure - upset emissions from low elevation sources
	4. Relative future population exposure - upset emissions from incinerator stack
	5. Relative future population exposure - upset emissions from low elevation sources
	6. Distribution of community facilities

cont...

TABLE 2.1: Summary of Risk Factors and Indicators (cont'd)

Factor	Indicator
R3. Risks from ingestion of cistern and pond water	1. Relative exposure from cistern and pond water - incinerator stack emissions
	2. Relative exposure from cistern and pond water - fugitive emissions
R4. Risks from consumption of crops and livestock	1. Relative sensitive crop exposure - incinerator stack emissions
	2. Relative sensitive crop exposure - fugitive emissions
	3. Relative sensitive livestock exposure - incinerator stack emissions
	4. Relative sensitive livestock exposure - fugitive emissions
	5. Relative future sensitive crop exposure - incinerator stack emissions
	6. Relative future sensitive crop exposure - fugitive emissions
	7. Relative future sensitive livestock exposure - incinerator stack emissions
	8. Relative future sensitive livestock exposure - fugitive emissions

dispersion and cause locally higher pollutant concentration levels and/or more frequent episodes of poor air quality. This is the second impact factor used. (It should be noted that this refers to local phenomena not included in the calculation of air quality increments under the air quality impact factor.)

As previously noted, emissions from the OWMC facility are expected to be well within applicable standards and guidelines. The standards are established under Regulation 308 of the Ontario Environmental Protection Act. The concentration increment due to the OWMC facility and compliance with the regulation may be calculated by a prescribed set of mathematical formulae, also given in Regulation 308. Concentrations of a given emission are calculated at downwind receptors under a given range of atmospheric conditions, and the maximum value compared with the applicable standard. The averaging period of the concentration is one-half hour. Special consideration is given to elevated receptors, such as escarpments and tall buildings, since these may experience higher concentrations than receptors at ground level. Guidelines (including provisional guidelines and tentative standards), established by the Ontario Ministry of the Environment, are applied in a similar manner.

Since there are no elevated receptors of sufficient height, either existing or planned, in the vicinity of OWMC's candidate sites, and Regulation 308 is not site-specific in any other respect, the increment due to OWMC and the degree of compliance with the standards and guidelines could not be used to differentiate between the different siting options.

Instead, alternative indicators were sought which would allow differentiation between sites at an appropriate level of detail.

Since the long-term dispersion climatology is somewhat different between sites, the dispersion of emissions around each site was mathematically modelled, taking into account the year round variations in wind and weather conditions. This was done for incinerator stack and fugitive emissions. The highest annual average concentrations were identified in

each case and compared with existing levels. These two indicators, for incinerator stack and fugitive emissions, were complemented by two other indicators which consider existing air quality levels in relation to annual air quality criteria and the potential for short-term episodes of poor air quality due to existing industries in the vicinity of each site. Further details of the methods of analysis are given in Chapter 3.

Under the restraints to dispersion factor, a single qualitative indicator was used, based on local topographic information.

The impact factors and indicators are summarized in Table 2.2. Appendix B contains a summary sheet for each indicator, similar to those shown for the risk indicators in Appendix A.

TABLE 2.2. Summary of Impact Factors and Indicators

Factor		Indicator
I1	Restraints to Dispersion	1. Local modifications to dispersion climatology
I2	Existing and Anticipated Air Quality	1. Existing air quality
		2. Existing short term air quality
		3. Estimated effect on air quality - incinerator stack emissions
		4. Estimated effect on air quality - fugitive emissions

3. METHODOLOGY

3.1 INTRODUCTION

Mathematical dispersion modelling was a major element in the analysis of the risk factors, specifically in the development of the exposure indices for population, crops and livestock, and cistern and pond water. The assessment of some of the impact factors also required the use of dispersion models. They were used to assess the air quality due to existing sources and the increment attributable to the OWMC facility. This chapter describes the dispersion modelling methodology in considerable detail and outlines the derivation of the exposure indices.

3.2 DISPERSION MODELLING

Mathematical dispersion modelling was used to represent the expected dispersion pattern of emissions from both the incinerator stack and from sources of fugitive emissions. The U.S. Environmental Protection Agency's (EPA's) Industrial Source Complex - Long Term model (ISCLT) (Bowers et al, 1979) was used, with the input of wind speed, direction and atmospheric stabilities representative of each location. This model was used in a previous study (ORF, 1984) to define existing air quality in the candidate areas. The relevant features of the model are outlined below.

The ISC model combines various dispersion model algorithms into a program that can be used to assess the air quality impact of emissions

from several source types associated with an industrial complex. The long-term version of the model was used (ISCLT), which is a sector averaged model. It uses statistical wind summaries to calculate seasonal or annual ground level concentration values using either a polar or Cartesian receptor grid. Major features include variable mixing height with stability, wind velocity vertical profile, plume rise as a function of downwind distance, and provisions for treatment of stack tip downwash and pollutant decay and deposition. Although some of these features were not needed for the simulation of background air quality and the dispersion of OWMC's emissions in the current evaluation, these features may be desirable at a later date for more detailed and site specific studies of the proposed facility. In the interests of consistency in modelling, it was felt desirable to use a model with this capability from the outset. If one or more of these options is not specified by the user, the program assigns preselected default values and, in fact, for regulatory applications in the U.S., the default values for these options are generally recommended (Bowers et al., 1979).

The ISC model treats the dispersion of each point source of emissions as a Gaussian plume, in which the concentration of a contaminant in the plume follows a normal distribution or "bell" curve. Area sources are treated as finite line sources. Concentrations are calculated at any point downwind as a function of source configuration, meteorological parameters, i.e., wind speed, atmospheric stability class (Pasquill-Gifford A to F), mixing height, as well as a function of downwind distance. In the long-term mode, ISC calculates concentrations at a given receptor for a complete range of meteorological parameters, and the results are weighted according to the frequency of occurrence of these parameters. The frequencies are obtained from the statistical wind and stability summaries over the averaging period of interest (i.e. one year).

The effective height of release for stack emissions is determined from the physical height of release (stack height) plus a plume rise due to the buoyancy and momentum of the flue gases. The plume rise may be calculated as a function of distance from the stack, otherwise the

ultimate rise is assumed regardless of distance from the stack. The lateral and vertical dispersion coefficients or plume spread are determined as functions of atmospheric stability and distance from the source. The conservatism created by not considering the deposition and decay of the plume have been noted. Such considerations should be more appropriately addressed in more detailed site specific studies.

The default values given in ISC for the change of wind speed with height were used. This is a function of atmospheric stability. Also, the rural mode of the model was used throughout the study area since the OWMC candidate sites are in predominantly rural or suburban surroundings. It should be noted that urban areas had been expressly excluded as a result of previous studies (ORF, 1982 and 1983). Therefore, atmospheric stability and the associated plume dispersion were not modified to take account of the urban heat island effect.

Terrain adjustment, in which the effective plume height is decreased to account for terrain elevations above that of the source, was not included at this stage of the study, since areas with significant topographic relief (e.g. the Niagara Escarpment) were excluded in an earlier phase of the site selection.

The dispersion modelling exercise required historical, hourly wind observations and other meteorological data from which Pasquill Gifford stability class frequencies could be determined (Atmospheric Environment Service, 1983, Environment Canada, 1982 and 1976). As only selected stations monitor these parameters on a regular basis, complete meteorological records from three representative stations were used.

The candidate sites north of Lake Ontario were represented by the last 10 years of climate data from Toronto Pearson International Airport. Winds at the Toronto station were predominantly from the north, but also included strong westerly to southerly components. Ground level wind speeds in the range of 4 to 5 m/s were experienced most frequently. The neutral stability class occurred approximately 55% of the time, with the

stable classes recorded 28% of time, and unstable classes recorded only 16% of the time.

The stability frequencies estimated from the St. Catharines Airport meteorological observations were felt to have been influenced by the presence of the lake, and would not have represented general dispersion conditions further south on the Niagara Peninsula. On the other hand, the St. Catharines wind data set was felt to be sufficiently representative of the east end of the Niagara Peninsula and was the most complete data set available for this region. Therefore, the candidate sites in the Niagara Peninsula were represented by St. Catharines wind data, with stability frequencies derived from observations at Mount Hope Airport, an inland station situated south of Hamilton. Winds in the region have relatively strong southwest and westerly components, with the most frequent wind speeds recorded in the range of 6 to 8 m/s.

Wind conditions across the candidate sites vary slightly, as represented by data at the two stations considered here. However, significant easterly components are absent in all areas, with westerly, southwesterly and northwesterly components dominating. Winds greater than 8 m/s and less than 2 m/s are experienced very infrequently, with the most common wind speeds occurring in the 4 to 8 m/s range. The St. Catharines station appears to experience higher wind speeds than does Toronto.

The modelling was performed out to a radius of 20 km for each incinerator site, and out to a radius of 5 km for sites with landfill only. The dispersion of fugitive emissions was also modelled out to 5 km. The region of maximum impact due to emissions from a 60 m stack is within 5 km of each site regardless of direction. However, a 20 km radius was chosen as the study area since, at this distance, the incremental effect on air quality is predicted to be negligible. The maximum impact due to fugitive emissions is expected to occur at the edge of the site. In this case, any incremental effect on air quality should fall to negligible levels within 5 km.

At each site, concentrations were calculated at 300 points within the 20 km radius (and 256 points within the 5 km radius) at the centre of each of the predetermined grid cells illustrated in Figure 3.1. The grid cell sizes were chosen to provide sufficient spatial definition in areas where the ground level concentration changes rapidly with respect to distance, e.g. it is expected that the concentration will increase relatively rapidly in the first 2 km downwind of the facility (as opposed to the 5 to 10 km range, for example), and so the grid cells are smaller in this area.

The results for each site were in the form of a set of isopleths or contours of concentrations at ground level which would result from a unit emission rate (1 g/s) of an undefined contaminant. These isopleths represent the annual average pattern of dispersion and reflect the general conditions of meteorology prevailing in a given area. Figures 3.2 to 3.14 illustrate the isopleths attributable to the fugitive emissions and the emissions from a 60 m stack, in units of micrograms per cubic metre (ug/m^3), for each of the candidate sites. Maximum ground level concentrations occur at various distances from the source and in different magnitudes, depending on meteorology, release height, plume buoyancy, etc. Table 3.1 summarizes the annual modelling results by presenting the maximum concentration for each source for the sites north and south of Lake Ontario.

3.3 DERIVATION OF RISK EXPOSURE INDICES

Other than the concentrations resulting from unit emission rates, the following additional data were required for the calculation of exposure indices:

- present and future population distributions around each site
- distribution of present and future sensitive crops around each site

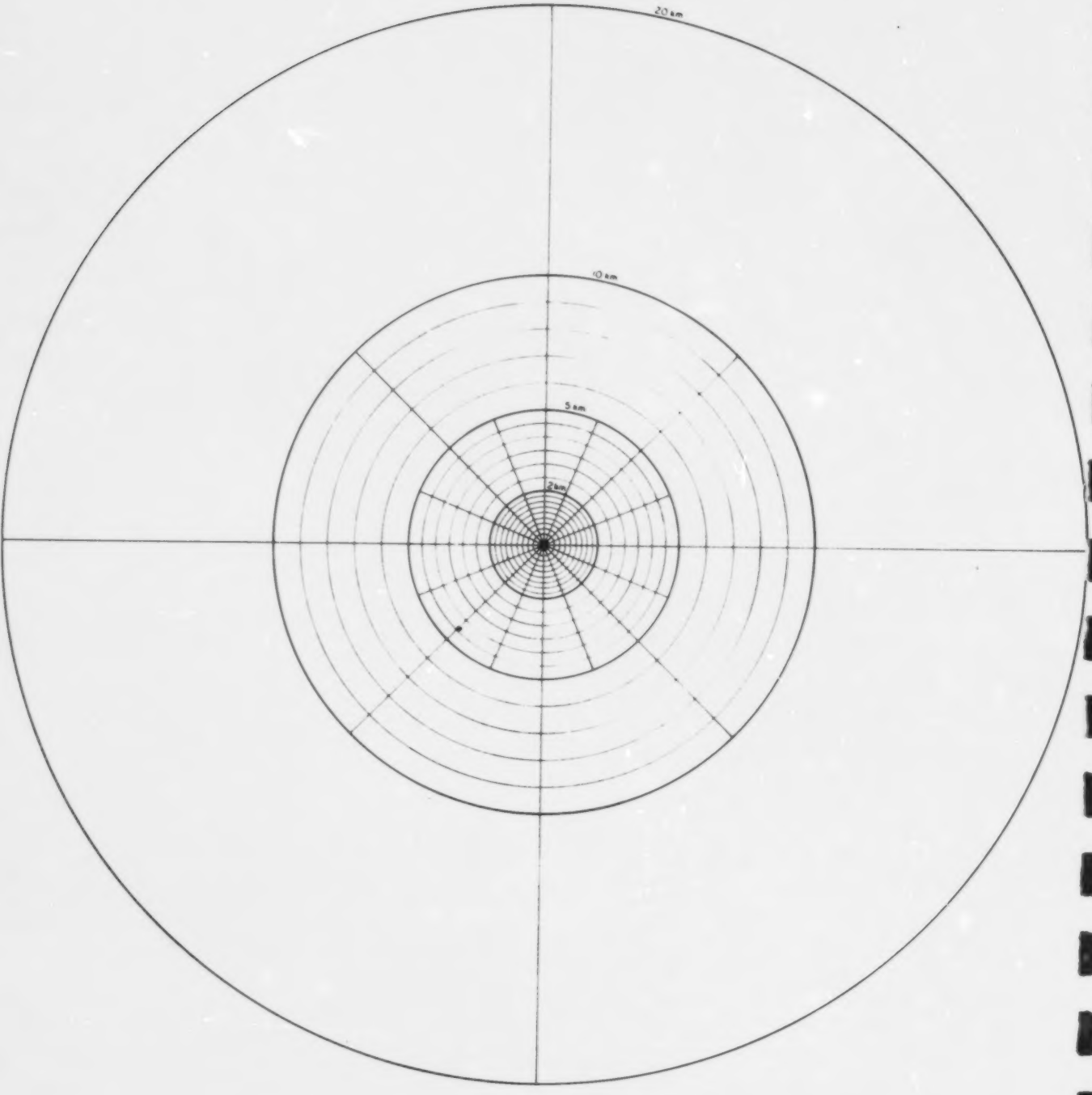


Figure 3.1 Reference Grid Cell Network Used in Site Specific Exposure Calculations

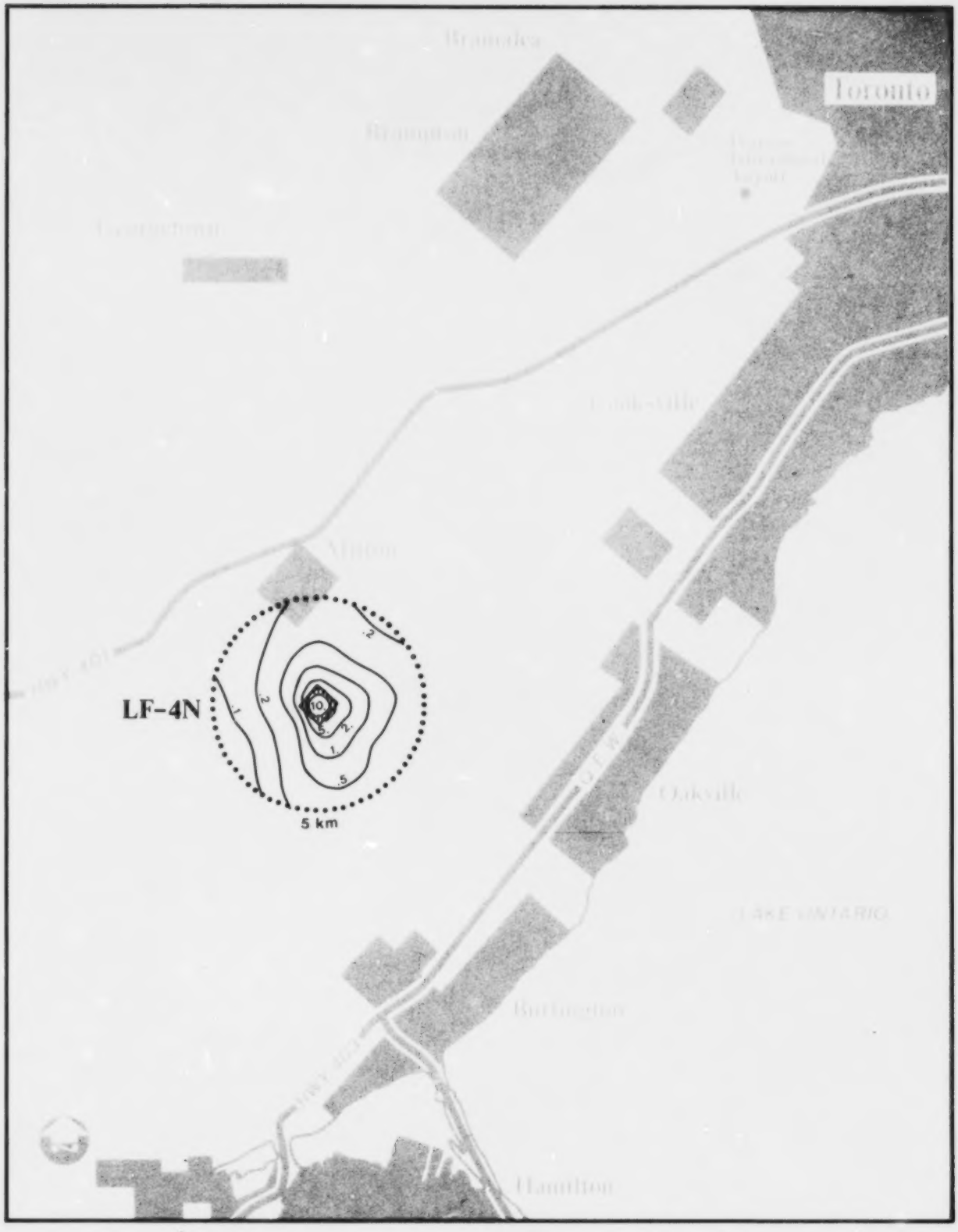


Figure 3.2

Fugitive Emissions Site LF-4N

Annual Concentration Isopleths (in μg/m³) for Unit Emission Rates (1 g/s)

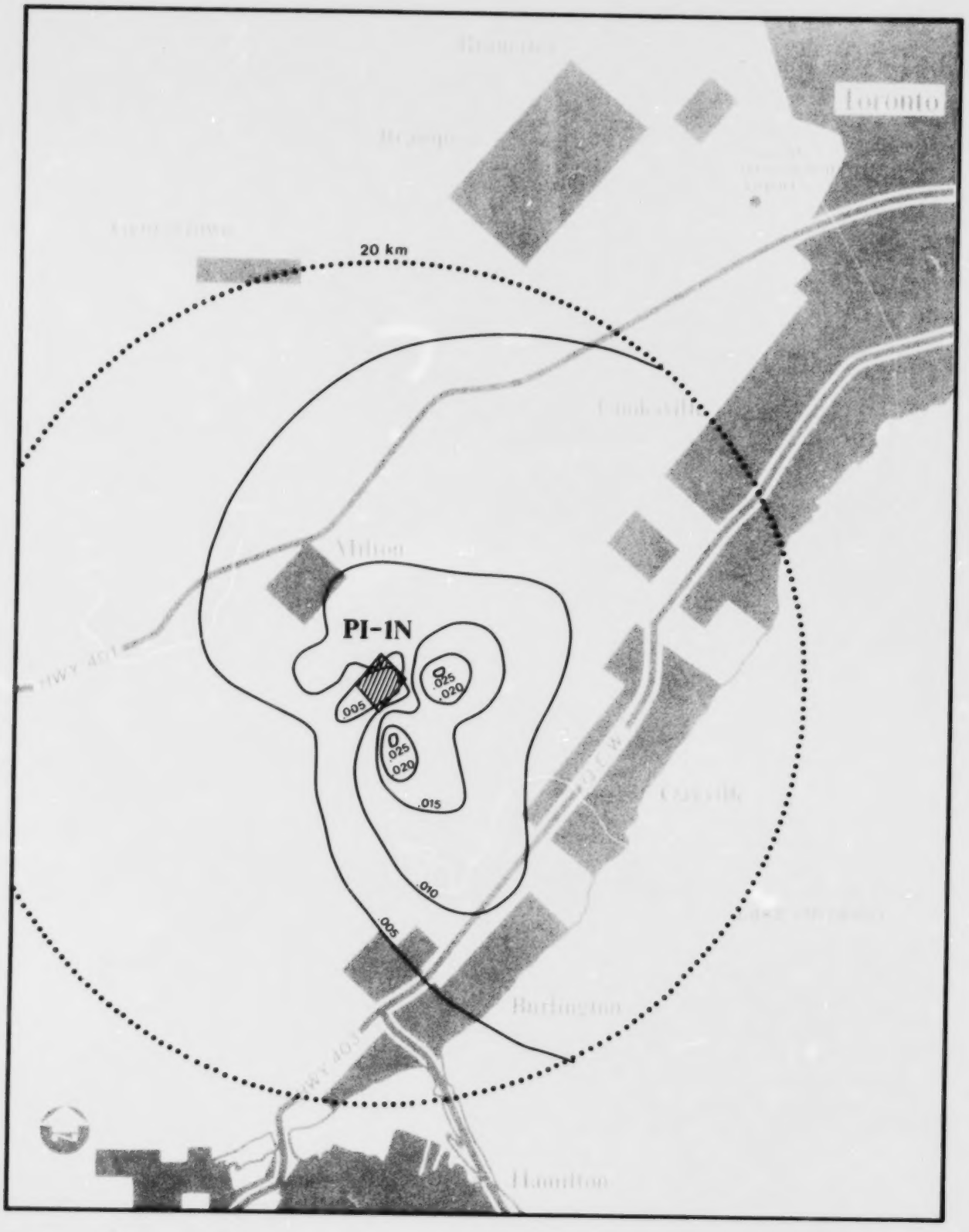


Figure 3.3

Incinerator Stack Emissions Site PI–1N

Annual Concentration Isopleths (in μg/m³) for Unit Emission Rates (1 g/s)

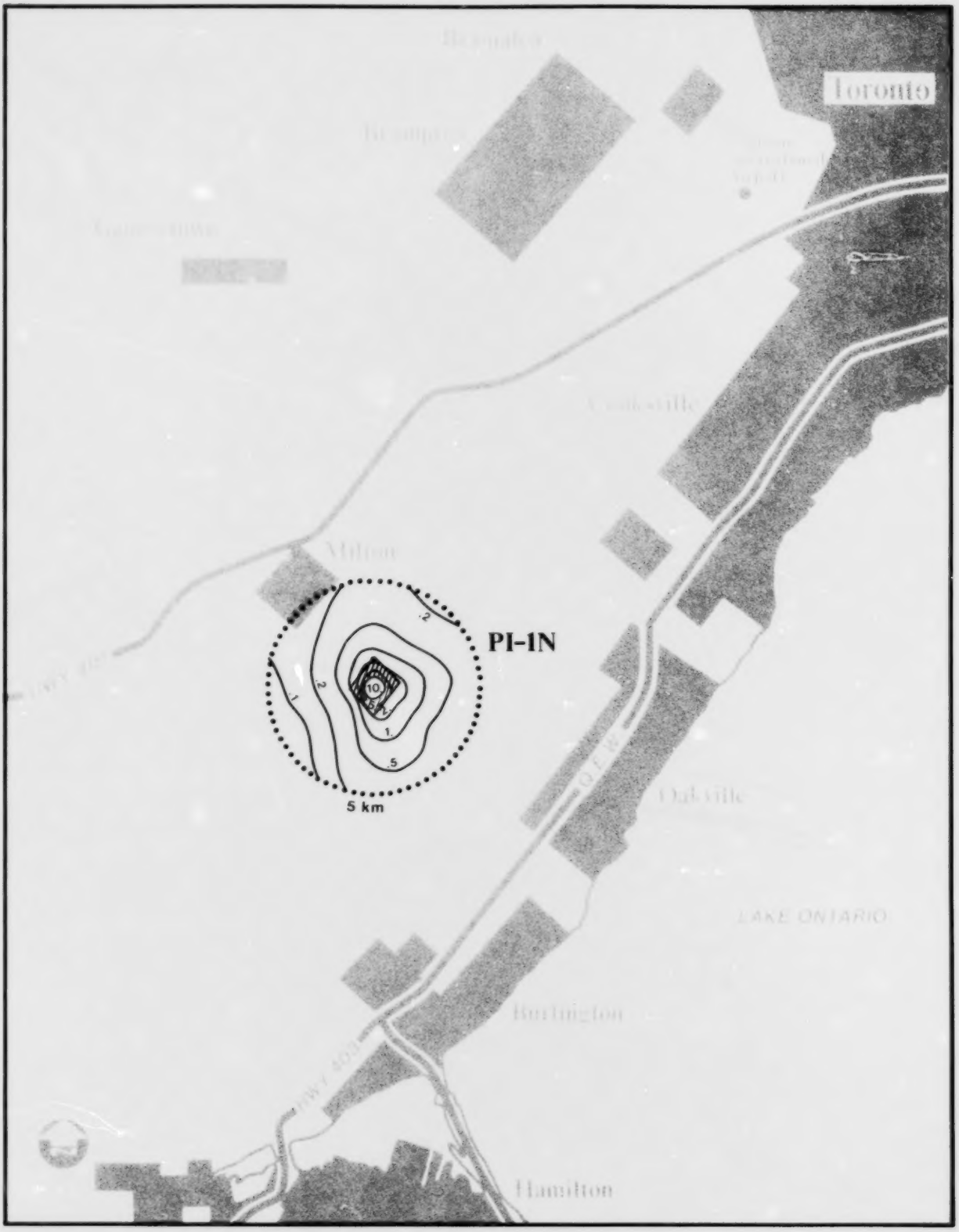


Figure 3.4

Fugitive Emissions Site PI–1N

Annual Concentration Isopleths (in μg/m³) for Unit Emission Rates (1 g/s)

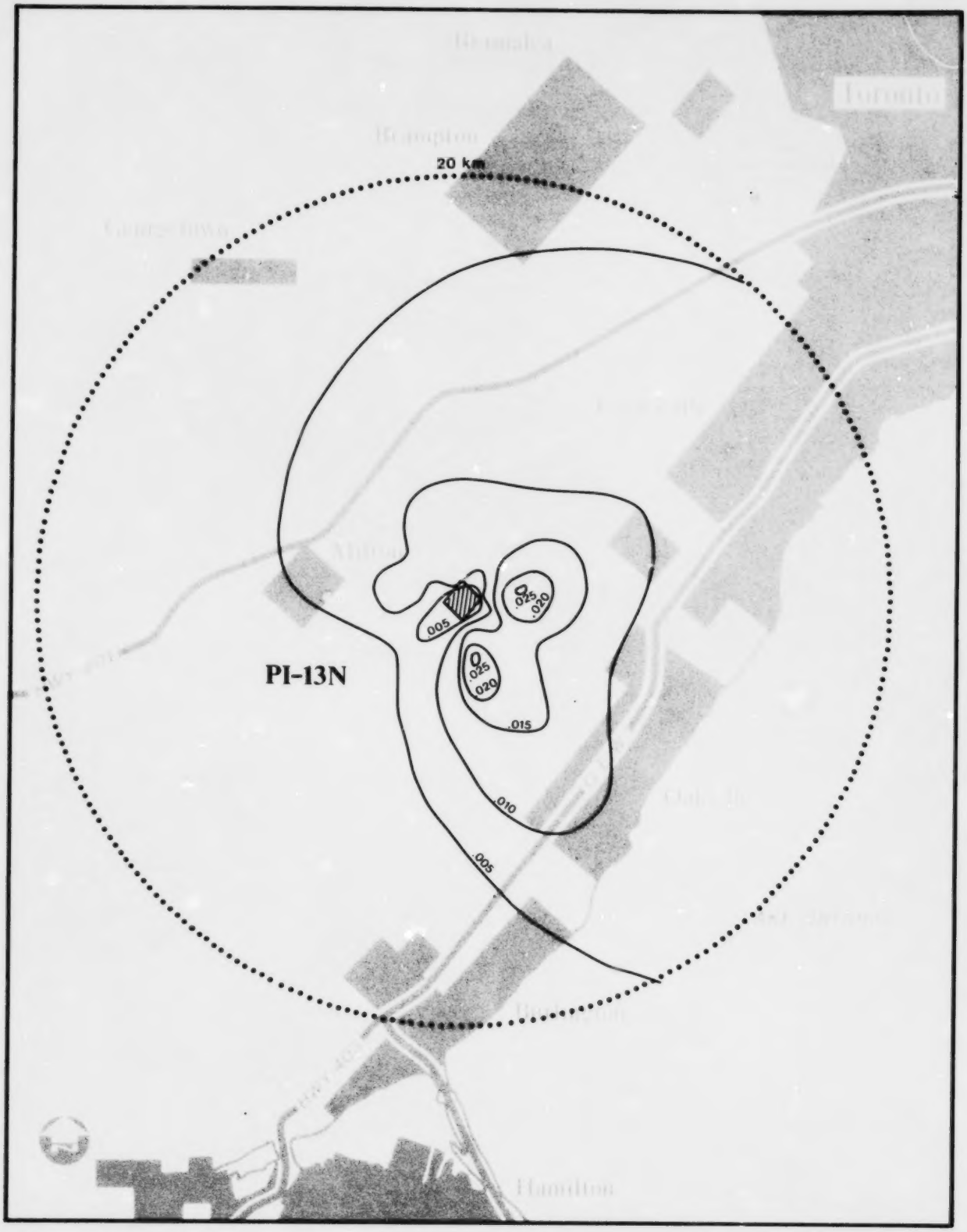


Figure 3.5

Incinerator Stack Emissions Site PI–13N

Annual Concentration Isopleths (in μg/m³) for Unit Emission Rates (1 g/s)

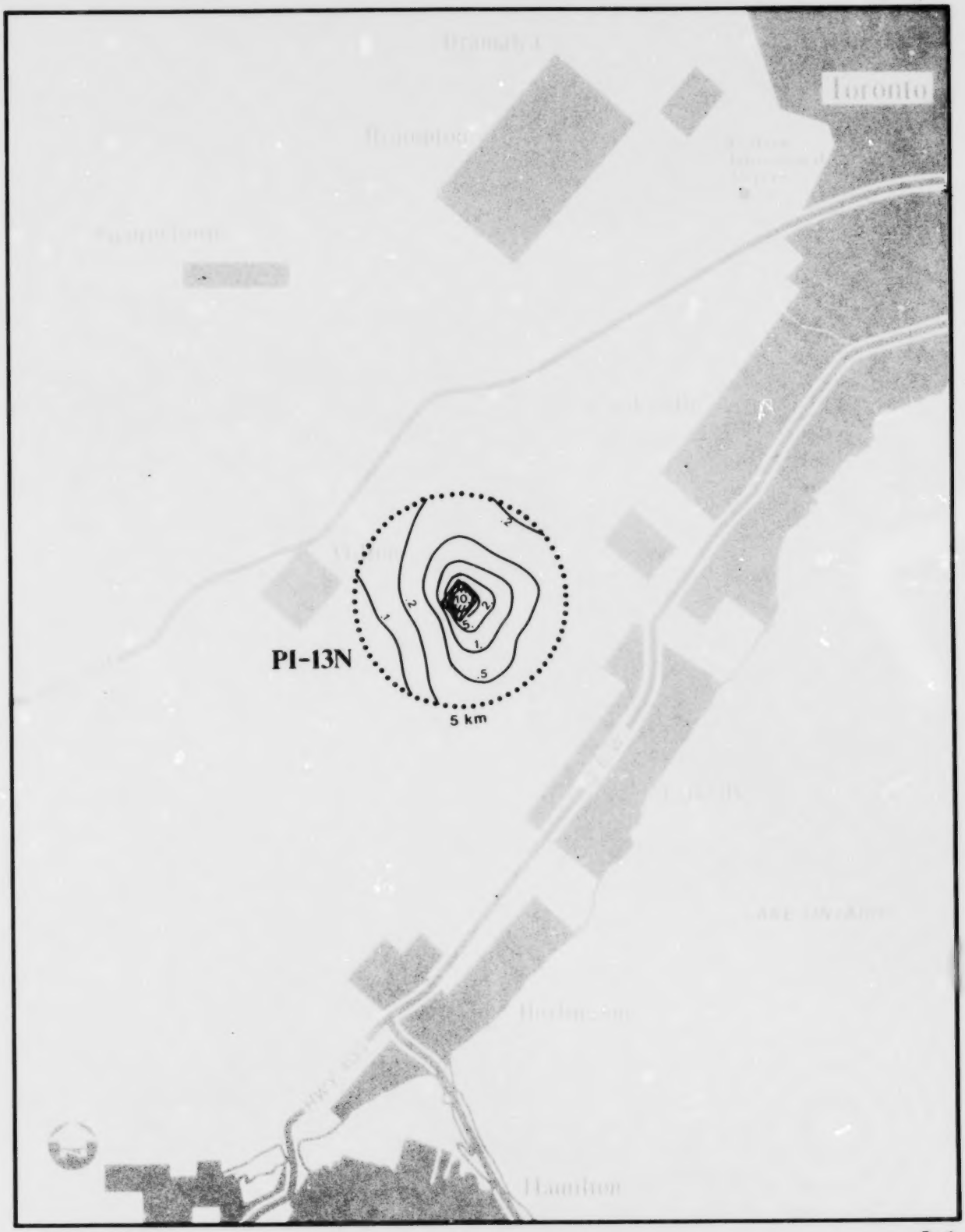


Figure 3.6

Fugitive Emissions Site PI-13N

Annual Concentration Isopleths (in μg/m³) for Unit Emission Rates (1 g/s)

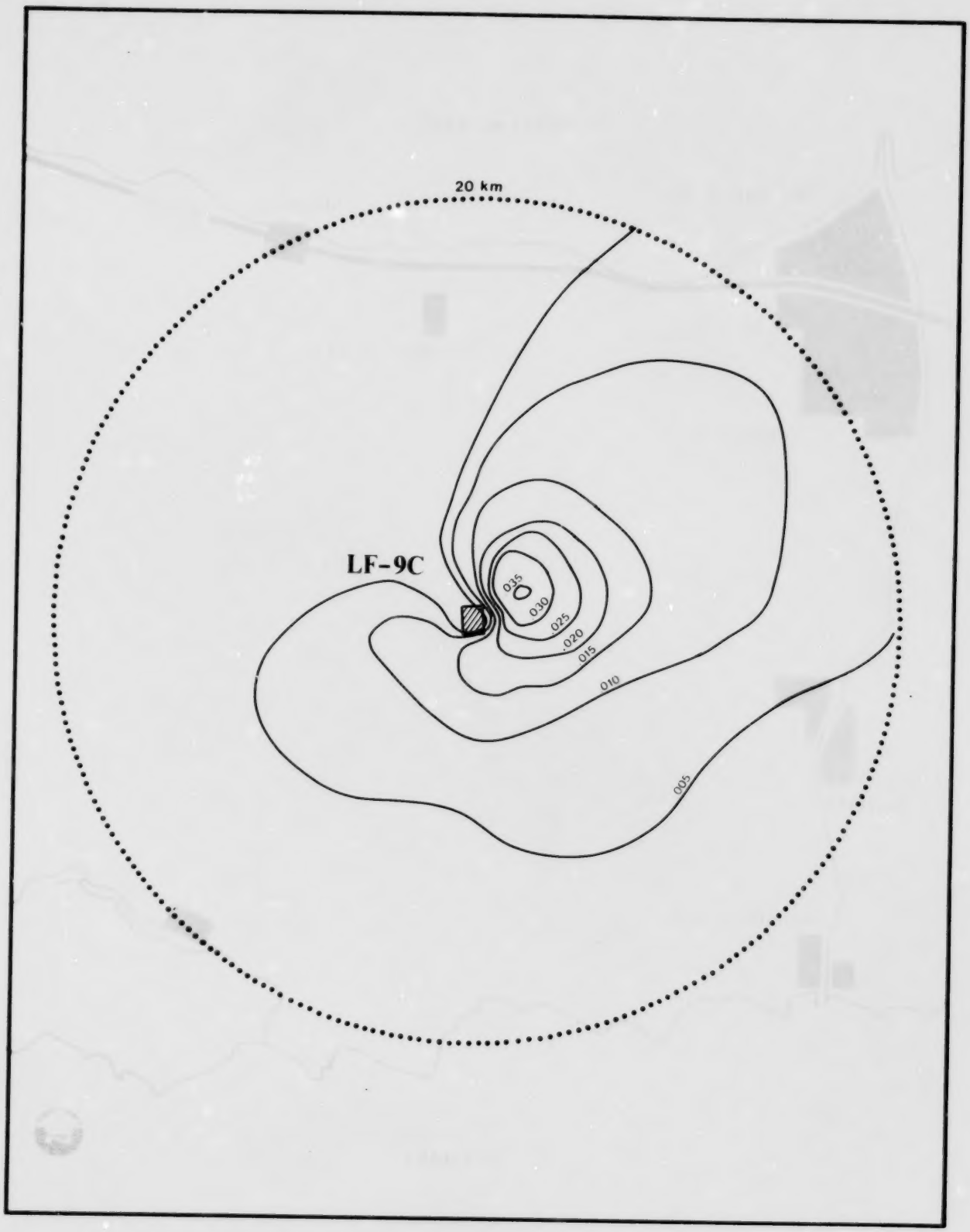


Figure 3.7

Incinerator Stack Emissions Site LF-9C

Annual Concentration Isopleths (in μg/m³) for Unit Emission Rates (1 g/s)

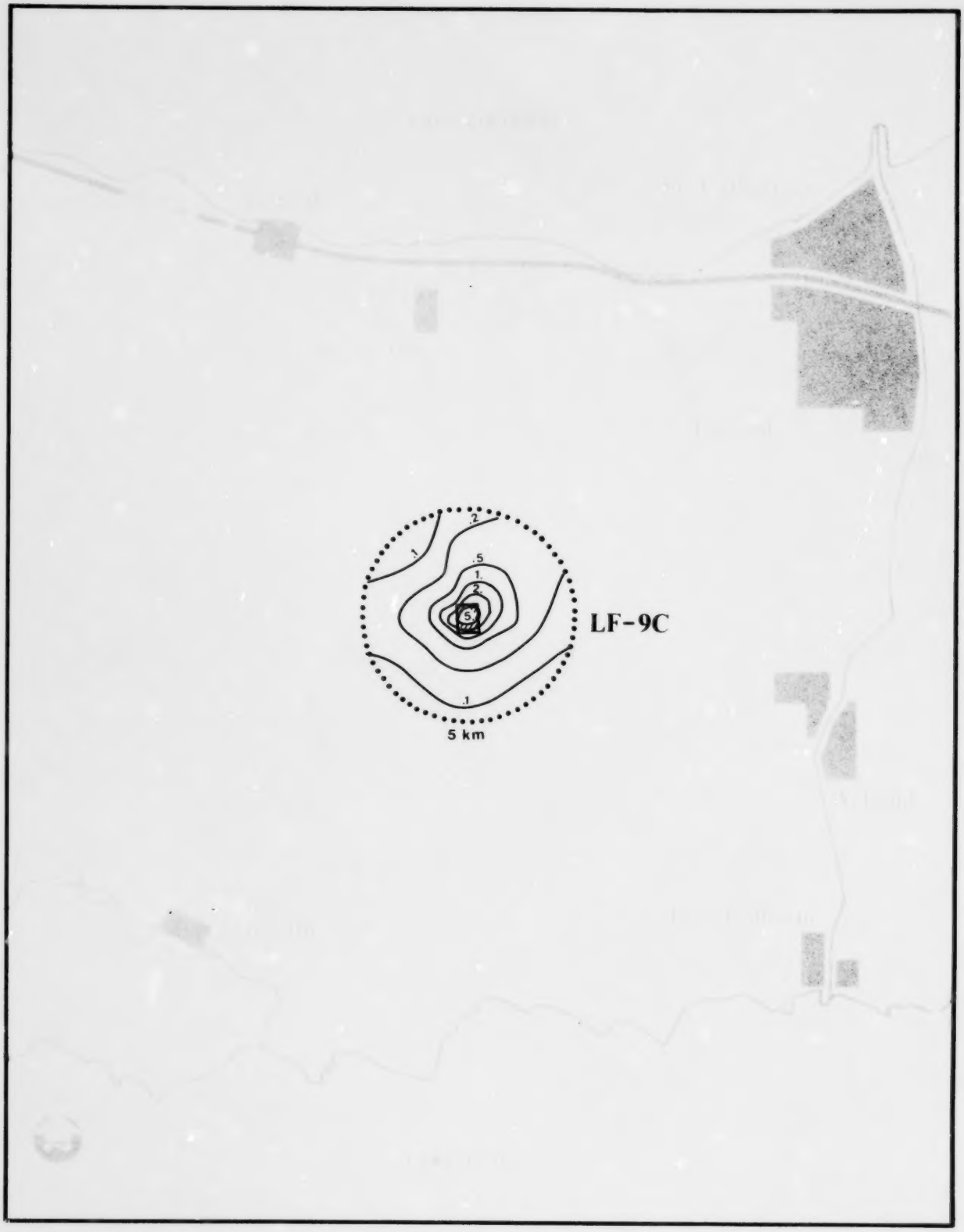


Figure 3.8

Fugitive Emissions Site LF-9C

Annual Concentration Isopleths (in μg/m³) for Unit Emission Rates (1 g/s)

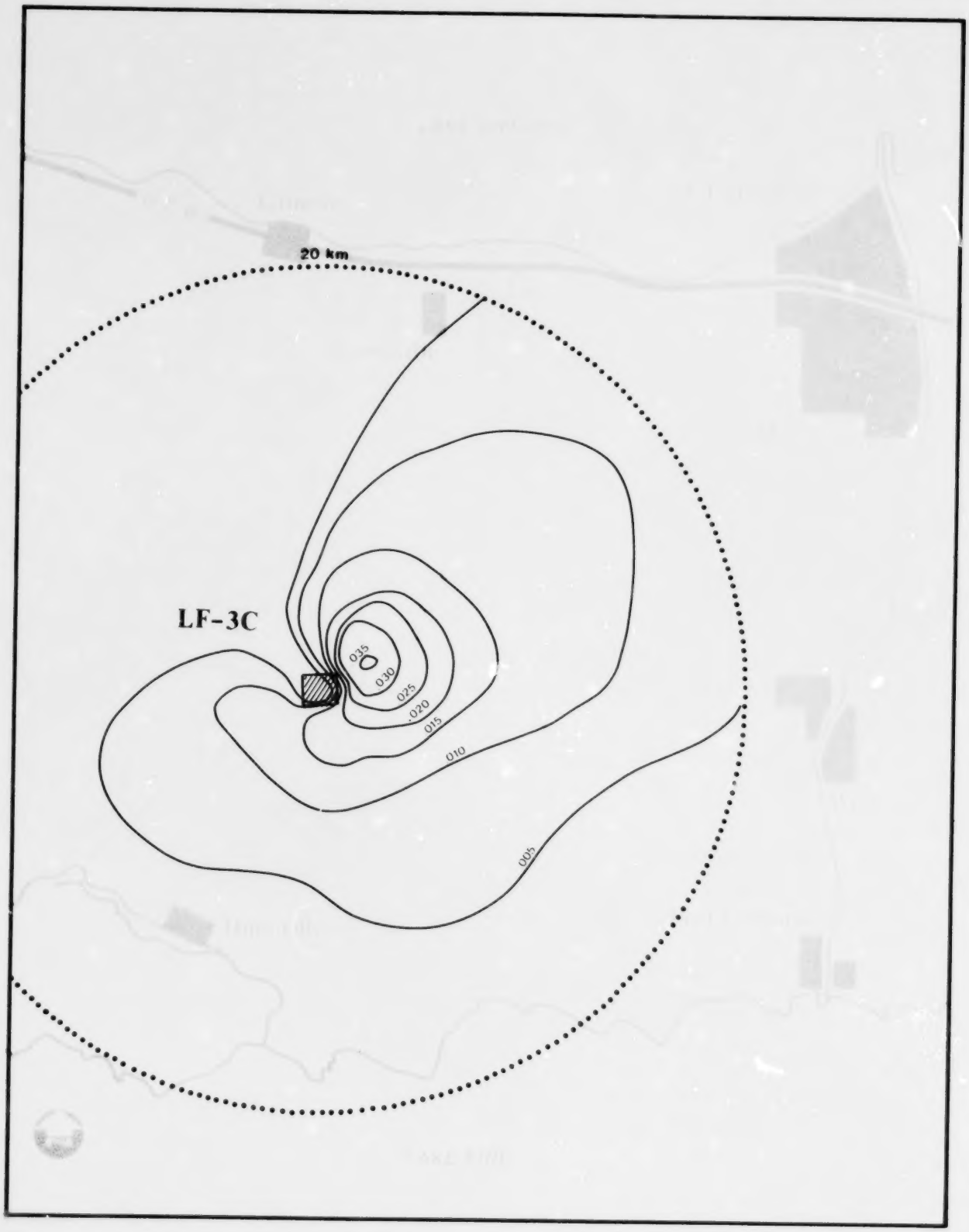
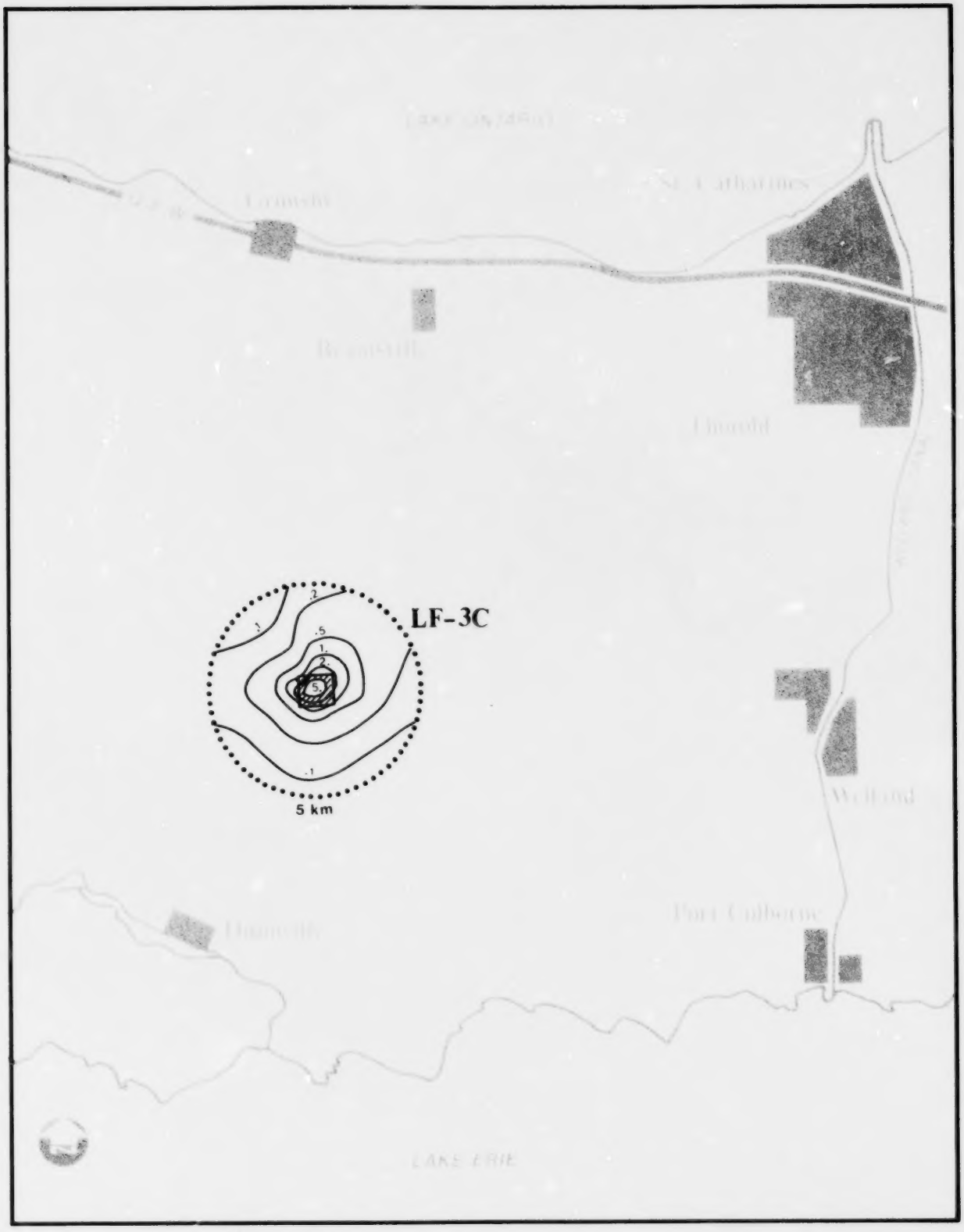


Figure 3.9

Incinerator Stack Emissions Site LF-3C

Annual Concentration Isopleths (in µg/m³) for Unit Emission Rates (1 g/s)



0 5 10 kilometres

Figure 3.10

Fugitive Emissions Site LF-3C

Annual Concentration Isopleths (in μg/m³) for Unit Emission Rates (1 g/s)

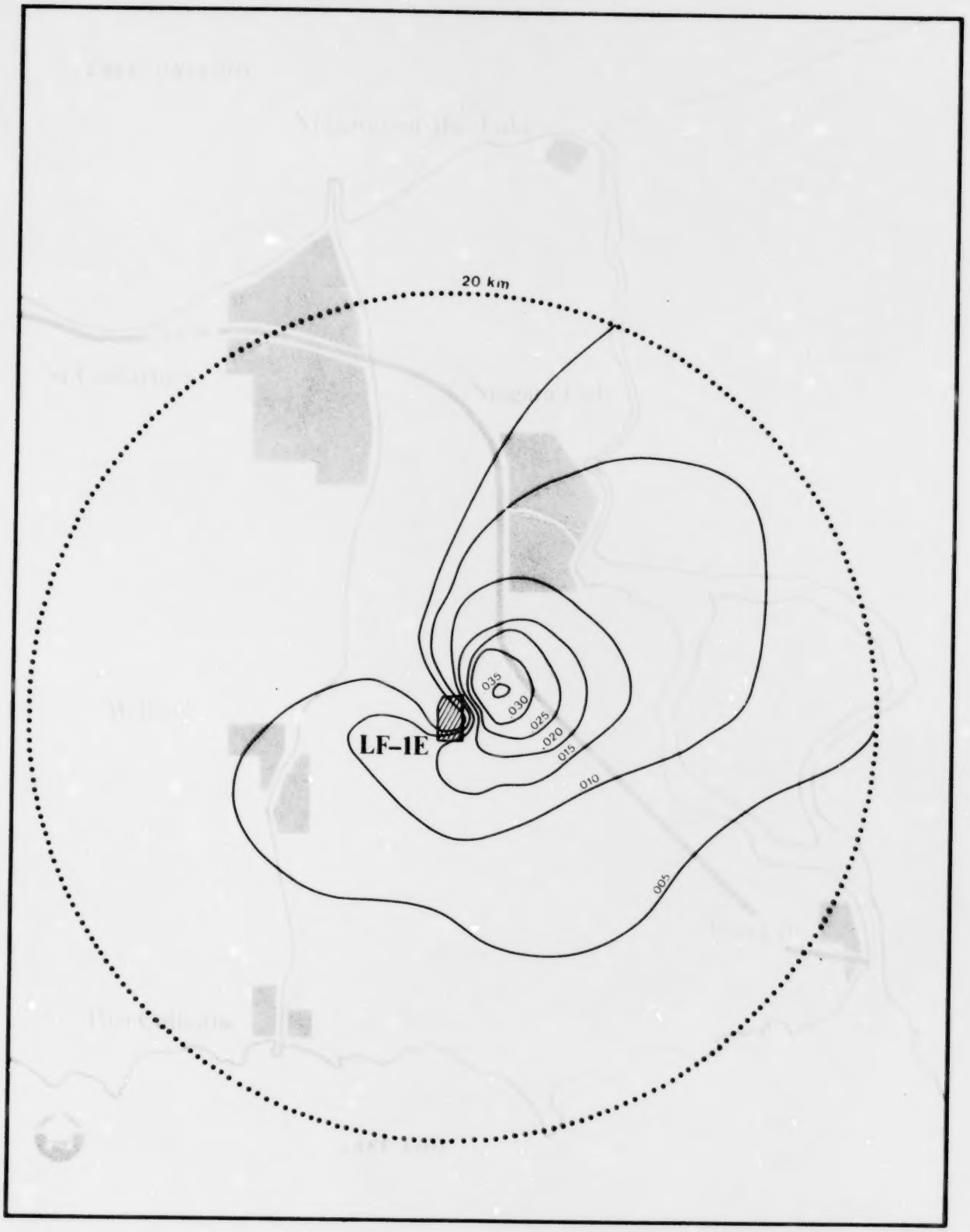


Figure 3.11

Incinerator Stack Emissions Site LF-1E

Annual Concentration Isopleths (in µg/m³) for Unit Emission Rates (1 g/s)

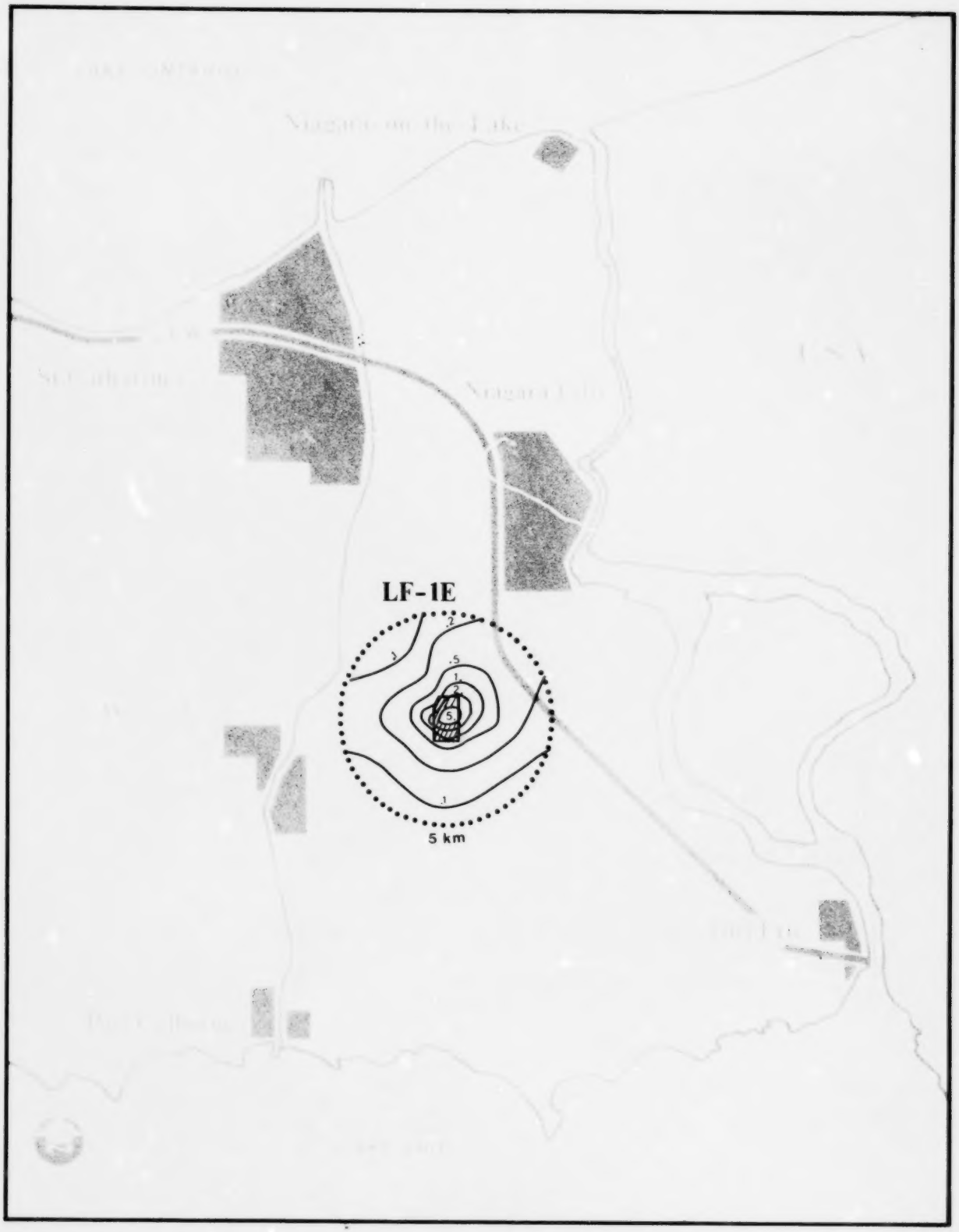


Figure 3.12

Fugitive Emissions Site LF-1E

Annual Concentration Isopleths (in µg/m³) for Unit Emission Rates (1 g/s)

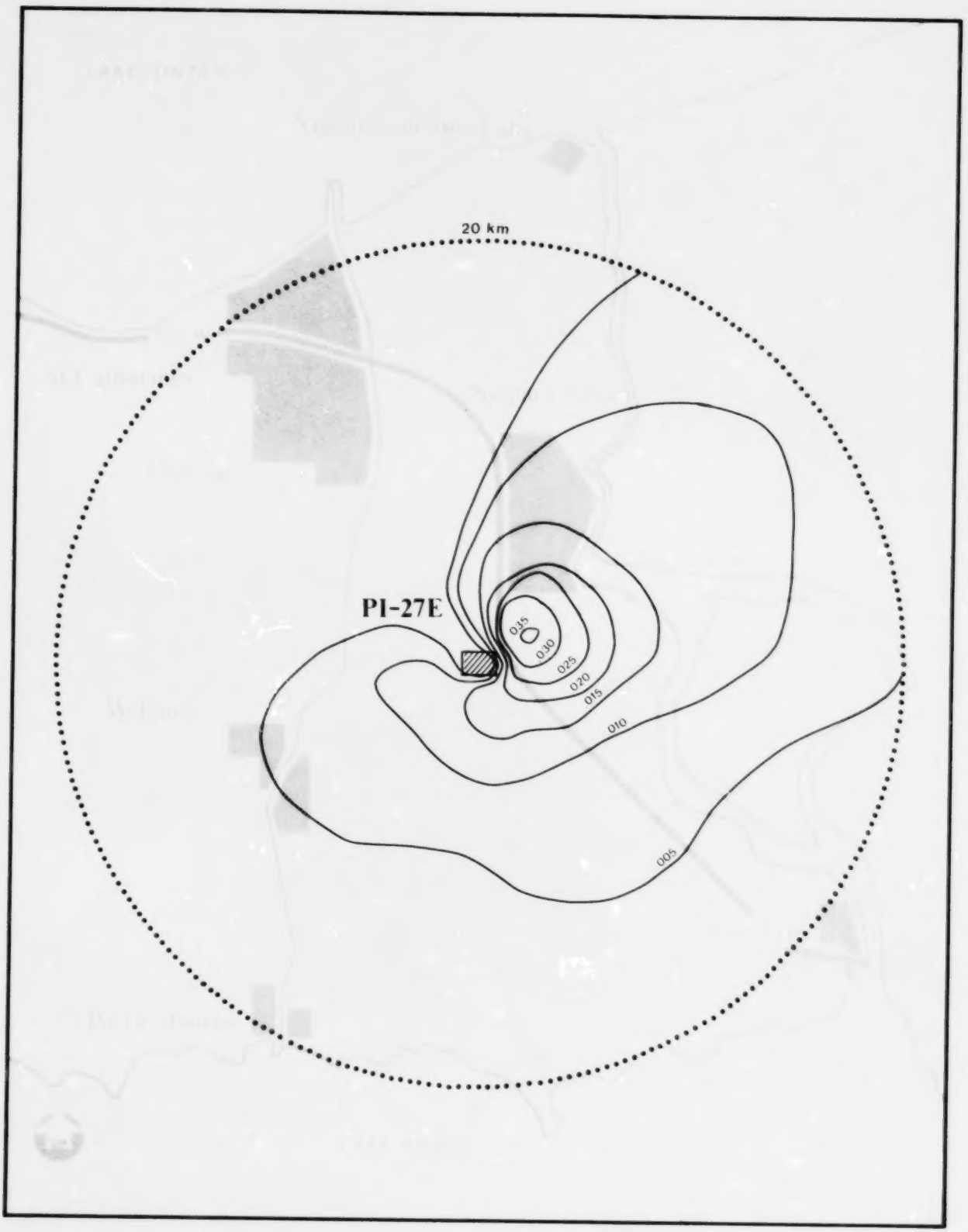


Figure 3.13

Incinerator Stack Emissions Site PI-27E

Annual Concentration Isopleths (in $\mu g/m^3$) for Unit Emission Rates (1 g/s)

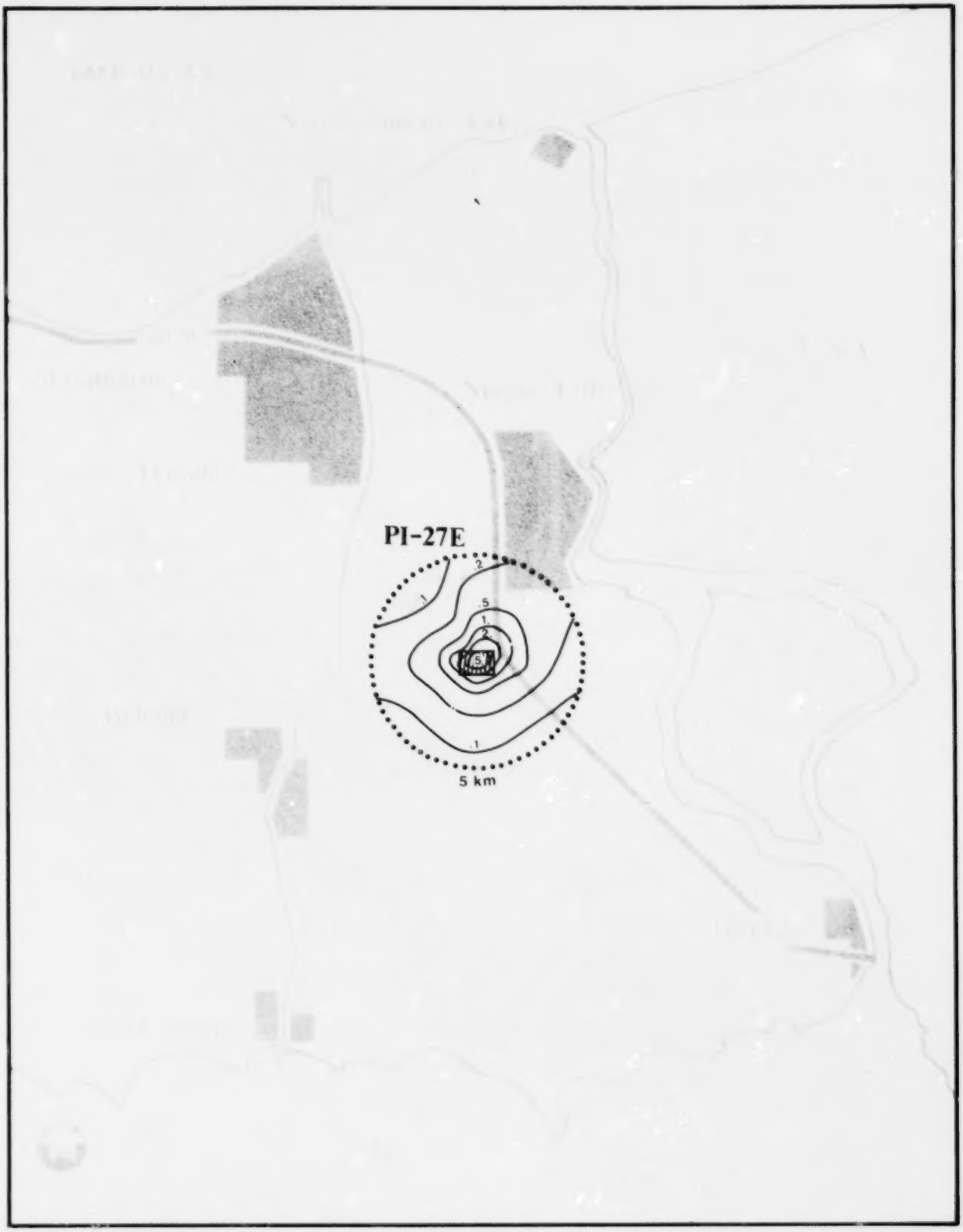


Figure 3.14

Fugitive Emissions Site PI-27E

Annual Concentration Isopleths (in $\mu g/m^3$) for Unit Emission Rates (1 g/s)

TABLE 3.1: Modelling Results -
Maximum Annual Average Concentrations at Ground Level

North of Lake Ontario

	Maximum Concentration ($ug/m^3/g/s$)	Distance (km)	Wind Direction
60 m stack	0.023	3.0	N-NNW W-WSW
Fugitive	23.50	0.4	N-NNW

South of Lake Ontario

	Maximum Concentration ($ug/m^3/g/s$)	Distance (km)	Wind Direction
60 m stack	0.036	2.75	SW-WSW
Fugitive	13.80	0.4	SW-SSW

Notes: Based on unit emission rate (1 g/s).
For incinerator stack, flue gas exit temperature 403 K, (130°C), flue gas exit velocity 20 m/s, equivalent stack diameter 1.84 m (2 flues of 1.3 m diameter each).

- distribution of present and future sensitive livestock around each site
- distribution of cisterns and ponds around each site

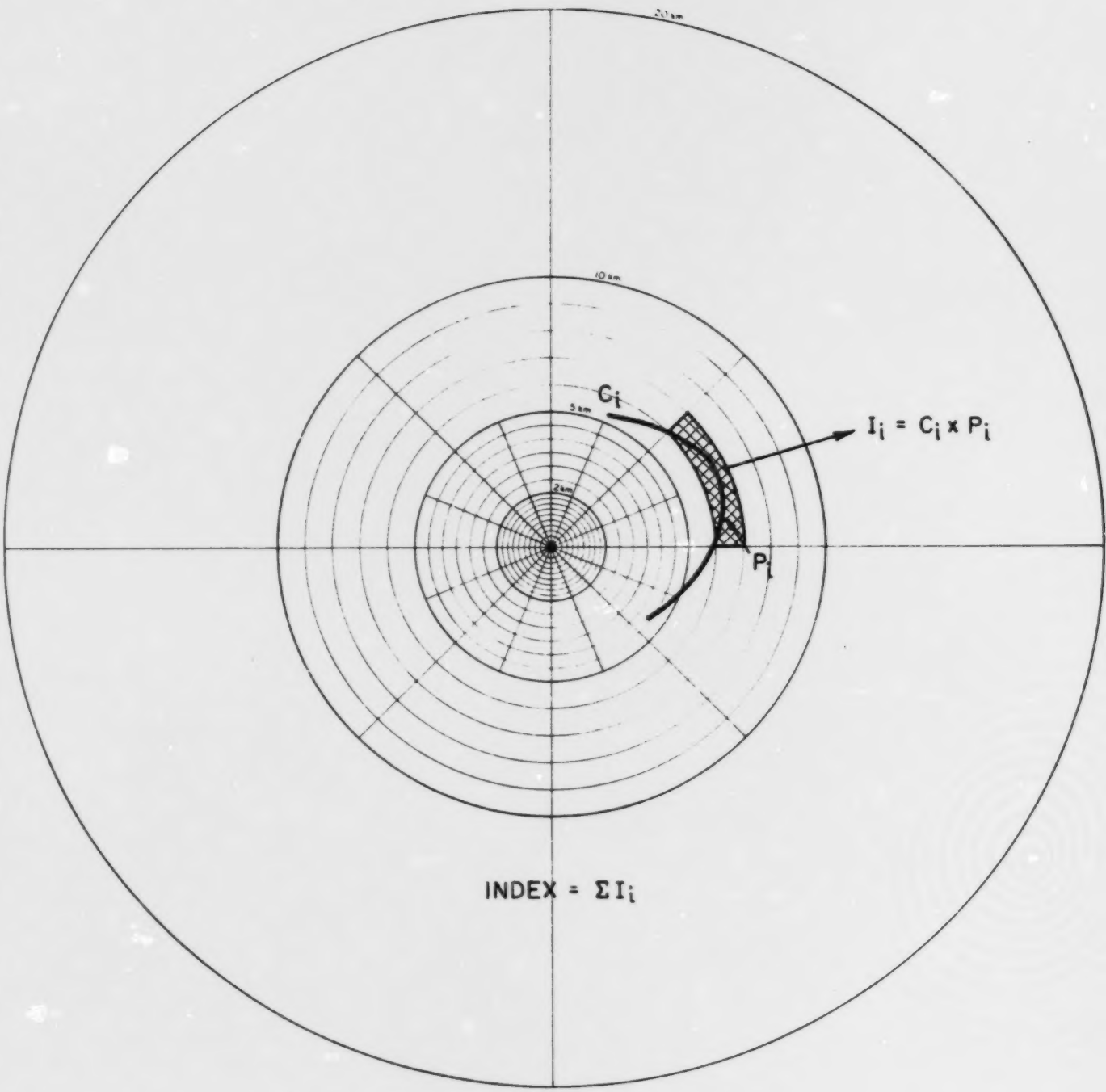
At each candidate site, the above data were combined with the predicted concentration at each grid cell to determine a series of chronic exposure indices for population, cisterns and ponds, and crops and livestock. Figure 3.15 illustrates how this was done.

In the case of the acute exposure indices, an analysis of potential short term (one-hour average or less) concentrations resulting from upset or accidental emissions, showed that the areas of maximum impact would be within a 5 km radius of the site in the case of incinerator stack emissions, and within a radius of 2 km of the site in the case of low elevation emissions. Since upset or accidental emissions could correspond with any wind direction, populations within these radii were used as the indices, regardless of direction from the candidate sites.

The results of the above analyses are provided as data matrices for each indicator in Appendix C.

3.4 DERIVATION OF AIR QUALITY IMPACT INDICES

The incremental effect on air quality due to the OWMC facility was calculated by multiplying the maximum concentration values (for the 60 m stack and fugitive cases) from Table 3.1 by the appropriate emission rate (Table 3.2) for each of the pollutants sulphur dioxide (SO_2), nitrogen oxides (NO_x), total suspended particulates (TSP) and total hydrocarbons (THC). These are the pollutants for which information on existing ambient concentrations is readily available for the candidate sites, and can be considered as surrogates for other pollutants commonly experienced in urban atmospheres. These are also some of the major contaminants which would be emitted by the OWMC facility.



I_i = Exposure index at grid i

C_i = Concentration at grid i

P_i = Population / crops / livestock / cisterns and ponds at grid i

FIGURE 3.15 Calculation Methodology for Exposure Indices

TABLE 3.2 Estimated Emission Rates for the OWMC Facility (ORF, 1985)

Pollutant	Emission Rate (g/s)	Source
SO_2	1.85	stack-incinerator
NO_x	1.85	stack-incinerator
TSP	0.37	stack-incinerator
	0.12	fugitive-landfill
	0.043	fugitive-phys/chem
	0.002	fugitive-incinerator
THC	0.10	stack-incinerator
	0.024	fugitive-incinerator
	0.0001	fugitive-phys/chem

The emission rates in Table 3.2 were estimated using published literature and reports. European and U.S. experience with liquid waste facilities was the main source of information. Since the emission rates were to be used in deriving annual average ambient air concentrations, the estimates were intended to be conservative but also to allow for periods when incinerator feed rate, and thus emission rates, are less than at design conditions (ORF, 1985). Thus, the estimates are lower than the maximum design emission rates given elsewhere (i.e. Monenco, 1985).

The following criteria were used to establish the estimates given in the table:

a) emission rates are less than the maximum design rates
b) values are in the range of values published for other comparable facilities
c) incinerator stack emissions are based on two rotary kilns operating at a combined average waste feed rate of 8.56 t/h with a flue gas exhaust flowrate of 44 320 Nm^3/h.

The results of the analyses are presented as data matrices for each indicator in Appendix C. Only two of the pollutants, i.e. SO_2, and TSP, have Ontario annual air quality criteria and, with the possible exception of TSP levels in the Niagara Falls area, it appears that most sites (with or without the facility) comply with these criteria. The incinerator stack emissions will have an insignificant effect on air quality at all sites, while the fugitive emission contribution will be relatively minor at all sites, compared to existing background levels.

Existing sources of emissions were studied over a radius of 5 km around each site, with the source data taken from the emission inventory compiled earlier (ORF, 1984). Maximum point-of-impingement concentrations for each source were superimposed to provide a worst case estimate of short term (one-half hour) levels of SO_2, NO_x, TSP and THC. Concentrations were calculated using procedures set out in Regulation 308 under the Environmental Protection Act.

It was not considered feasible to attempt predictions of background air quality over the life of the OWMC facility, i.e., future air quality which would prevail if the facility were not built. However, in general, the estimates of existing levels, and the relative levels between candidate sites, are expected to prevail in the foreseeable future.

4. CONTRIBUTION TO SELECTION OF PREFERRED LOCATION FOR THE PHYSICAL/CHEMICAL TREATMENT PLANT

4.1 INTRODUCTION

As discussed in Chapter 5 of this report, three of the siting options studied in the detailed comparative evaluation involved two sites. A study was undertaken to assess, for each partially integrated siting option, the preferred location for the physical/chemical treatment plant (the landfill and incinerator sites were pre-determined). This chapter provides the basis for recommendations made from the standpoint of air quality and atmospheric dispersion. These recommendations were then considered, along with similar inputs from other site-selection disciplines. The following three partially integrated siting options were ultimately selected for study in the detailed comparative evaluation:

LF1E/PI27E (landfill at LF1E, incinerator and physical/chemical treatment plant at PI27E)

LF4N/PI1N (landfill at LF4N, incinerator and physical/chemical treatment plant at PI1N)

LF4N/PI13N (landfill at LF4N, incinerator and physical/chemical treatment plant at PI13N).

4.2 ANALYSIS OF OPTIONS

The site specific data shown in Appendix C under each indicator were used to assign suitability levels to the siting options (also given in

Appendix C - assignment of suitability levels is described in Chapter 5). The analysis of the six possible partially integrated siting options was carried out using these suitability levels, for those factors and indicators considered applicable to atmospheric emissions from the physical/chemical treatment plant. The indicators concerned with health risk are the population, crop, livestock, cistern and pond water exposure indices due to fugitive or low elevation emissions from this plant only, since emissions from the incinerator stack are not involved. The indicators concerned with general air quality impacts are the existing air quality and the effects of fugitive emissions from the physical/chemical plant, expressed in terms of the concentrations of total suspended particulates (TSP) and total hydrocarbons (THC) only. Emissions of the other two pollutants considered in this study (sulphur dioxide and nitrogen oxides) are associated with the incinerator and not the physical/chemical treatment plant. As well, the indicator which addresses local modifications to dispersion climatology is used in the analysis, since the dispersion of fugitive emissions from the treatment plant could be affected.

Table 4.1 compares the two options, which involve sites LF4N and PI1N. The suitability levels given against each indicator are from Appendix C and are associated with the site at which the physical/chemical treatment plant would be located under the given option. Tables 4.2 and 4.3 provide similar comparisons for the LF4N/PI13N and LF1E/PI27E options, respectively.

4.3 PREFERRED LOCATIONS

The preferred siting option within each pair was assessed based on the suitability levels shown in Tables 4.1 to 4.3, and the significance of each indicator in relation to the expected emissions from the physical/chemical treatment plant.

TABLE 4.1

Comparison of Locations of Physical/Chemical Treatment Plant

LF4N vs PI1N

Factor	Indicator	Suitability Levels for Physical/Chemical Treatment Plant at: LF4N	PI1N
R1 Risks from Direct Inhalation of Emissions - Chronic	2. Relative population exposure - fugitive emissions	- 4.9	- 4.1
	4. Relative future population exposure - fugitive emissions	- 3.2	- 3.5
R2 Risks from Direct Inhalation of Emissions - Acute	1. Topographic features on or around site	- 1.0	- 5.0
	3. Relative population exposure - upset emissions from low elevation sources	- 1.0	- 2.5
	5. Relative future population exposure - upset emissions from low elevation sources	- 1.0	- 2.6
	6. Distribution of community facilities	- 5.0	- 5.0
R3 Risks from Ingestion of Cistern and Pond Water	2. Relative exposure from cistern and pond water - fugitive emissions	- 1.5	- 1.3
R4 Risks from Consumption of Crops and Livestock	2. Relative sensitive crop exposures - fugitive emissions	- 5.0	- 4.1
	4. Relative sensitive livestock exposures - fugitive emissions	- 2.3	- 2.0
	6. Relative future sensitive crop exposures - fugitive emissions	- 5.0	- 4.1
	8. Relative future sensitive livestock exposures - fugitive emissions	- 2.3	- 2.0
I1 Restraints to Dispersion	1. Local modifications to dispersion climatology	- 5.0	- 5.0
I2 Existing and Anticipated Air Quality	1. Existing air quality	- 1.0	- 1.0
	2. Existing short term air quality	- 1.0	- 1.0
	4. Estimated effect on air quality - fugitive emissions	- 5.0	- 5.0

TABLE 4.2

Comparison of Locations of Physical/Chemical Treatment Plant
LF4N vs PI13N

Factor	Indicator	Suitability Levels for Physical/Chemical Treatment Plant at: LF4N	PI13N
R1 Risks from Direct Inhalation of Emissions - Chronic	2. Relative population exposure - fugitive emissions	- 4.9	- 2.8
	4. Relative future population exposure - fugitive emissions	- 3.2	- 3.9
R2 Risks from Direct Inhalation of Emissions - Acute	1. Topographic features on or around site	- 1.0	- 5.0
	3. Relative population exposure - upset emissions from low elevation sources	- 1.0	- 5.0
	5. Relative future population exposure - upset emissions from low elevation sources	- 1.0	- 5.0
	6. Distribution of community facilities	- 5.0	- 1.6
R3 Risks from Ingestion of Cistern and Pond Water	2. Relative exposure from cistern and pond water - fugitive emissions	- 1.5	- 2.1
R4 Risks from Consumption of Crops and Livestock	2. Relative sensitive crop exposures - fugitive emissions	- 5.0	- 4.6
	4. Relative sensitive livestock exposures - fugitive emissions	- 2.3	- 2.8
	6. Relative future sensitive crop exposures - fugitive emissions	- 5.0	- 4.6
	8. Relative future sensitive livestock exposures - fugitive emissions	- 2.3	- 2.8
I1 Restraints to Dispersion	1. Local modifications to dispersion climatology	- 5.0	- 3.0
I2 Existing and Anticipated Air Quality	1. Existing air quality	- 1.0	- 1.3
	2. Existing short term air quality	- 1.0	- 1.0
	4. Estimated effect on air quality - fugitive emissions	- 5.0	- 5.0

TABLE 4.3

Comparison of Locations of Physical/Chemical Treatment Plant
LF1E vs PI27E

Factor	Indicator	Suitability Levels for Physical/Chemical Treatment Plant at: LF1E	PI27E
R1 Risks from Direct Inhalation of Emissions - Chronic	2. Relative population exposure - fugitive emissions	- 1.8	- 5.0
	4. Relative future population exposure - fugitive emissions	- 1.2	- 5.0
R2 Risks from Direct Inhalation of Emission - Acute	1. Topographic features on or around site	- 1.0	- 1.0
	3. Relative population exposure - upset emissions from low elevation sources	- 4.5	- 1.8
	5. Relative future population exposure - upset emissions from low elevation sources	- 3.4	- 1.0
	6. Distribution of community facilities	- 1.0	- 2.7
R3 Risks from Ingestion of Cistern and Pond Water	2. Relative exposure from cistern and pond water - fugitive emissions	- 5.0	- 1.0
R4 Risks from Consumption of Crops and Livestock	2. Relative sensitive crop exposures - fugitive emissions	- 1.4	- 1.0
	4. Relative sensitive livestock exposures - fugitive emissions	- 1.6	- 1.0
	6. Relative future sensitive crop exposures - fugitive emissions	- 1.5	- 1.0
	8. Relative future sensitive livestock exposures - fugitive emissions	- 1.7	- 1.0
I1 Restraints to Dispersion	1. Local modifications to dispersion climatology	- 1.0	- 1.0
I2 Existing and Anticipated Air Quality	1. Existing air quality	- 4.4	- 5.0
	2. Existing short term air quality	- 2.2	- 5.0
	4. Estimated effect on air quality - fugitive emissions	- 1.0	- 1.0

The impact indicators were not considered significant compared with some of the risk indicators for the following main reasons:

- o sites with significant restraints to dispersion were excluded in previous site selection stages,
- o incremental effects due to emissions from the treatment plant are very small (3% or less for TSP) or negligible (close to 0% for THC),
- o any restraints on emissions from the treatment plant due to other sources of emissions in the vicinity are unlikely but could be relatively easily accommodated, due to the very small emission quantities and the flexibility afforded by the batch operations employed.

On the other hand, a generic risk assessment of the proposed OWMC facility (Environ, 1985) found that the mixing of incompatible wastes during treatment could result in the release of a significant quantity of toxic vapours. While the risk assessment did not predict any adverse health effects on the surrounding population (an adjusted margin of safety of 27 - see Table 5.2), such a scenario is considered of greater concern than the relatively small routine or chronic emissions from the physical/chemical treatment plant. Therefore, the choice of preferred options was based primarily on the direct inhalation indicators for acute emissions.

In the comparison of sites LF4N and PI1N (see Table 4.1), there was no difference in suitability levels with respect to impact indicators. Six out of eleven risk indicators suggested a preference for PI1N. However, LF4N was more suitable under three of the four indicators concerned with direct inhalation of acute emissions. The two sites were equivalent under the fourth indicator (distribution of community facilities). Since greatest weight was given to these acute risk indicators, site LF4N was considered more suitable than PI1N as the location of the physical/chemical treatment plant.

In the comparison of sites LF4N and PI13N (see Table 4.2), there was again no significant difference on the basis of the impact indicators. The greater suitability of LF4N suggested under the existing air quality indicator was considered minor. The majority of risk indicators favoured LF4N, including three of the four indicators concerned with direct inhalation of acute emissions (the distribution of community facilities favoured PI13N). Overall, therefore, site LF4N was considered more suitable than PI13N.

Consideration of the final pair of options, involving sites LF1E and PI27E, resulted in no clear preference. The impact indicators suggested a preference for LF1E, although, as argued above, little weight was given to these indicators when considering emissions from the physical/chemical treatment plant. Two of the four risk indicators for acute emissions clearly favoured PI27E and one clearly favoured LF1E. The risk indicators for direct inhalation of chronic emissions clearly favoured LF1E. There was little difference between the options with respect to risks from consumption of crops and livestock. The exposure index for cistern and pond water consumption clearly favoured PI27E.

Finally, it should be emphasized that atmospheric emissions from the physical/chemical treatment plant are expected to be minor, relative to other facility components. Furthermore, the generic risk assessment did not predict any adverse health effects from potential upset emissions. Thus, while preferred siting options have been indicated in two of the three comparisons, air quality and atmospheric dispersion factors are considered to be of only minor significance in the overall selection of partially integrated siting options.

5. DETAILED COMPARATIVE EVALUATION

5.1 INTRODUCTION

A total of thirteen siting options was originally identified by OWMC for detailed comparative evaluation in Phase 4A of the site selection studies (Dillon, 1985). In May 1985, LF2N in Mississauga was dropped as a candidate site for reasons relating to its hydrogeologic suitability. Considerations of risks and impacts due to atmospheric emissions did not play a part in this decision. The locations of the physical/chemical treatment plant in the partially integrated options were subject to study in the early stages of this work. This included a comparative assessment of the effects on air quality associated with locating this plant at each of the two sites comprising the partially integrated option, e.g. at sites LF1E and PI27E. This aspect of the work was described in Chapter 4.

The following six siting options remained for the detailed comparative evaluation:

Integrated Options

- LF3C
- LF9C
- LF1E

Partially Integrated Options

LF1E/PI27E (landfill at LF1E, incinerator and physical/chemical treatment plant at PI27E)

LF4N/PI1N (landfill at LF4N, incinerator and physical/chemical treatment plant at PI1N)

LF4N/PI13N (landfill at LF4N, incinerator and physical/chemical treatment plant at PI13N)

This chapter describes the assignment of relative suitability levels to the six siting options. It also explains the rationale for weighting the various risk and impact factors and indicators identified earlier in Chapter 2. The establishment of suitability levels and indicator weightings were used to determine an order of preference of the siting options under each factor and the two factor groupings (risks and impacts). The results of this analysis are also given.

5.2 BASIC ACCEPTABILITY

Before ranking the siting options, it is important to address the question of their basic acceptability from the standpoint of air quality and atmospheric dispersion and whether or not, on these grounds, any of the options should be dropped. None of the options were considered to be unsuitable at this stage, for the following principal reasons:

a) dispersion analysis of potential atmospheric emissions from the proposed OWMC facility showed that such emissions would be well within applicable air quality standards and guidelines at all candidate sites,

b) studies of existing long-term air quality and the expected increments in concentration due to the proposed facility (see Chapter 3) show that the impacts would be minor to negligible at all sites,

c) areas in the Golden Horseshoe region which would be expected to experience relatively poor conditions of atmospheric dispersion

and, thus, relatively frequent episodes of poor air quality, were excluded from consideration in an earlier phase of the site selection process,

The data base for each siting option was reviewed for each factor and indicator, and it was determined that screening of any factors or indicators was not warranted.

5.3 SUITABILITY LEVELS FOR THE SITING OPTIONS

The results of the site-specific data analysis under each indicator were used to assign the suitability levels to the siting options. These results have been tabulated in Appendix C. The suitability levels range from -1.0 to -5.0. Within each indicator, a level of -1.0 was assigned to the most suitable siting option (with the least risk or impact), while a level of -5.0 was assigned to the least suitable siting option (with the greatest risk or impact). This convention was adopted to be compatible with the overall site selection methodology and the suitability levels used by other consultants in their respective technical disciplines. For the indicators used here, this convention is considered appropriate to represent the relative differences in risks and impacts between sites.

Siting options which, for any given indicator, were intermediate between the most suitable and least suitable options, were assigned a suitability level according to the numerical value of the parameter representing that indicator. Thus, a site option having a parameter value exactly mid-way between the parameter values of the most suitable and least suitable options would have a level of -3.0. In the case of the few indicators which did not have a numerical parameter, the suitability levels were assigned on a subjective basis using three levels of relative suitability, i.e., -1.0 (least risk or impact), -3.0 (intermediate risk or impact) and -5.0 (greatest risk or impact).

The partially integrated siting options involve two sites, thus introducing a potential complication to assigning an appropriate suitability level. However, the generic risk assessment conducted on behalf of OWMC (Environ, 1985) showed that the most significant risks to public health would be associated with stack and fugitive emissions from the incinerator. Thus, suitability levels under all risk factors and indicators were assigned according to the incinerator site, i.e. PI27E (in the case of option LF1E/PI27E), PI1N (in the case of LF4N/PI1N), and PI13N (in the case of option LF4N/PI13N).

The method of establishing suitability levels for the partially integrated siting options under the impact factors and indicators varied according to the indicator in question (see Appendix C). In general, however, the suitability level adopted for a given option was that determined for the less suitable of the two sites involved in that option.

It should be noted that suitability levels relating to risks and impacts from stack emissions have been determined for the present reference design, which includes a 60 m stack. In the early stages of this study, an alternative stack height of 100 m was investigated. However, this was found to have no effect on the relative suitabilities of the siting options.

Finally, it should be emphasized that the suitability levels are intended to reflect the relative suitability of the siting options. This evaluation of risks and impacts associated with each siting options showed that, in absolute terms, all options are acceptable for the siting of the OWMC facilities.

5.4 WEIGHTING OF FACTORS AND INDICATORS

5.4.1 RISK FACTORS

As previously identified in Chapter 2, four factors involving twenty indicators relating to the risk to human health from atmospheric

emissions were used in the comparative evaluation of the six siting options. Weighting was performed at the indicator level according to three main criteria:

a) the severity of the risk associated with the pathways represented by the indicator
b) the frequency and duration of the associated effect, and
c) the potential for remedial action or mitigation.

The severity of the risk was estimated in a separate generic risk assessment of the OWMC facilities (Environ, 1985). This study used a "worst case" approach to estimate the risks from different categories of emissions and different pathways to man, including incinerator stack and fugitive emissions, routine and upset or accidental emissions, the direct inhalation pathway and the indirect pathways via crops, livestock and cistern and pond water. Risks were presented in terms of an individual cancer risk, for chronic exposures to routine emissions, and an adjusted margin of safety, for acute exposures to upset or accidental emissions. The results are summarized in Tables 5.1 and 5.2.

The risk assessment found that the risks to human health associated with chronic exposure to the potential air emissions can be considered acceptable and not such as to pose a significant health hazard (Environ, 1985). In this regard, it is noted that the U.S. EPA currently views a cancer risk of 1×10^{-6} as acceptable. However, in view of some present uncertainties surrounding the character and quantity of the wastes to be treated, the character and quantity of the emissions, and the detailed design of the facility, as well as the possibility of some upset or accidental emissions which could have adverse acute effects (see Table 5.2), it is considered prudent to consider the exposure of the population to the facility emissions in the site selection process. With this objective in mind, the results of the risk assessment indicate the relative significance of the various pathways to humans, and thus the relative weight which might be attached to the corresponding exposure

TABLE 5.1: Summary of Results of Generic Risk Assessment - Chronic Exposures (Environ, 1985)

Exposure Pathway	Individual Lifetime Cancer Risk**	
	Fugitive Emissions	Incinerator Stack Emissions
Direct Inhalation	1×10^{-6}*	9×10^{-7}
Cisterns and Ponds	2×10^{-8}	2×10^{-7}
Crops	4×10^{-8}	2×10^{-7}
Livestock - Meat	7×10^{-11}	2×10^{-7}
- Milk	5×10^{-11}	1×10^{-7}

Notes:

* Indicates an individual lifetime cancer risk of one in a million.

** In all cases, the risks are of a magnitude not considered to pose a significant human health hazard, either individually or in combination.

TABLE 5.2: Summary of Results of Generic Risk Assessment - Acute Exposures (Environ, 1985)

Source of Exposure	Adjusted Margin of Safety **
Short-term, low elevation (tank farm fire)	0.02
(mixing of incompatible wastes)	27.0
Short-term, incinerator stack (scrubber failure)*	
- SO_2	0.06
- NO_x	2.0
- HCl	0.5
- HF	10.0

Notes:

* Incinerator stack scrubber failure based on simultaneous failure of scrubbers on both incinerator units.

** If the Adjusted Margin of Safety (AMOS) is one or greater, the predicted levels of exposure are sufficiently low to avoid the potential for an acute health effect. In cases where the AMOS value is less than one, this is an indicator of the potential for some level of effect, although this may not necessarily be an adverse health effect.

indices, e.g. direct population exposure by inhalation versus exposure through consumption of livestock.

To convey the relative importance of different indicators, and to be consistent with other aspects of the overall site selection studies, indicators have been assigned weightings on a five-point scale from 1 (least significant) to 5 (most significant). In view of the high priority given by OWMC to the protection of human health, risk indicators representing pathways with the highest chronic or acute risk (see Tables 5.1 and 5.2) were assigned a weighting of 5. Other indicators and path-days were then assigned weightings using the above mentioned criteria, with regard to their significance relative to the highest weighted indicators.

Table 5.3 summarizes the risk indicator weightings and the rationale for these weightings.

Since weightings were assigned at the indicator level, it should be noted that each factor weighting is the arithmetic mean of the contributing indicator weightings.

5.4.2 IMPACT FACTORS

Two factors consisting of five indicators were used to characterize the general air quality impacts at each site, including the atmospheric dispersion conditions. Again, weighting was performed at the indicator level. In this case, three main criteria were used in this weighting process:

a) the likelihood of an effect associated with the indicator,
b) the severity of the associated effect, and
c) the potential for remedial action or mitigation.

As with the risk factors and indicators, the numerical weighting scheme was consistent with other aspects of the overall site selection

TABLE 5.3: Basis for Risk Indicator Weightings

Factor	Indicator	Weighting	Reason for Weighting and Comments
R1 Risks from Direct Inhalation of Emissions-Chronic	1. Relative population exposure-incinerator stack emissions 3. Relative future population exposure-incinerator stack emissions	5	• predicted lifetime cancer risk 10^{-6} at point of maximum concentration; worst case analysis • continuous exposure • limited opportunity for for detection and mitigation
	2. Relative population exposure - fugitive emissions 4. Relative future population exposure - fugitive emissions	5	• predicted lifetime cancer risk 10^{-6} at edge of buffer zone; worst case analysis • continuous exposure • limited opportunity for detection and mitigation
R2 Risks from Direct Inhalation of Emissions-Acute	1. Topographic features on or around site	1	• heavy vapour release may be concentrated by significant slopes and depressions on or near site • minor or no effect at all sites, since sites are relatively flat

cont'd...

TABLE 5.3: Basis for Risk Indicator Weightings (cont'd)

Factor	Indicator	Weighting	Reason for Weighting and Comments
Risks from Direct Inhalation of Emissions - Acute (cont'd)	2. Relative population exposure - upset emissions from incinerator stack 4. Relative future population exposure- upset emissions from incinerator stack	3	• based on scrubber failure • margin of safety less than 1 at point of maximum concentration for HCl and SO_2 release • any potential health effects mild and reversible • scrubber failure relatively frequent but mitigatable through operating procedures
	3. Relative population exposure - upset emissions from low elevation sources 5. Relative future population exposure- upset emissions from low elevation sources 6. Distribution of community facilities	5	• based on tank farm fire • potentially severe for individuals in immediate proximity of site; margin of safety less than 1 • likelihood of event expected to be remote • mitigation cannot be assumed, but effects may be reduced by fast response and contingency planning • effects may occur before remedial action possible

TABLE 5.3: Basis for Risk Indicator Weightings (cont'd)

Factor	Indicator	Weighting	Reason for Weighting and Comments
R3 Risks from Ingestion of Cistern and Pond Water	1. Relative exposure from cistern and pond water-incinerator stack emissions	3	• predicted lifetime cancer risk 10^{-7}; worst case analysis • continuous exposure • indirect pathway - possible (but difficult) to monitor contaminant levels and take remedial action prior to long-term risk to human health
	2. Relative exposure from cistern and pond water - fugitive emissions	3	• predicted lifetime cancer risk 10^{-8}; worst case analysis • continuous exposure • indirect pathway-possible (but difficult) to monitor contaminant levels and take remedial action prior to long-term risk to human health
R4 Risks from Consumption of Crops and Livestock	1. Relative sensitive crop exposures - incinerator stack emissions 5. Relative future sensitive crop exposure-incinerator stack emissions	3	• predicted lifetime cancer risk 10^{-7}; worst case analysis • continuous exposure • indirect pathway-possible (but difficult) to monitor contaminant levels and take remedial action prior to long-term risk to human health

TABLE 5.3: Basis for Risk Indicator Weightings (cont'd)

Factor	Indicator	Weighting	Reason for Weighting and Comments
R4 Risks from Consumption of Crops and Livestock (cont'd)	2. Relative sensitive crop exposures - fugitive emissions 6. Relative future sensitive crop exposures-fugitive emissions	3	• predicted lifetime cancer risk 10^{-8}; worst case analysis • continuous exposure • indirect pathway - possible (but difficult) to monitor contaminant levels and take remedial action prior to long-term risk to human health
	3. Relative sensitive livestock exposures - incinerator stack emissions 7. Relative future sensitive livestock exposures - incinerator stack emissions	3	• predicted lifetime cancer risk 10^{-7}; worst case analysis • continuous exposure • indirect pathway - possible (but difficult) to monitor contaminant levels and take remedial action prior to long-term risk to human health
	4. Relative sensitive livestock exposures - fugitive emissions 8. Relative future sensitive livestock exposures - fugitive emissions	1	• predicted lifetime cancer risk 10^{-10}; worst case analysis • continuous exposure • indirect pathway - possible (but difficult) to monitor contaminant levels and take remedial action prior to long-term risk to human health

studies, and used a five-point scale from 1 (least significant) to 5 (most significant).

Air quality impact indicators have been assigned relatively low weightings due to the small incremental effects on ambient air quality which are likely to result from the facility emissions. On an annual average basis, these are 1% or less for the incinerator stack emissions, and 10% or less for fugitive emissions (based on existing and projected levels of SO_2, NO_x, TSP and T.C - see Appendix C). In addition, another report (e.g. Monenco, 1985) indicates that incinerator emissions will be well within ambient standards and guidelines for half-hour average concentrations. For most contaminants, such emissions would be less than 1% of the corresponding standards and guidelines.

Sites having significant restraints to dispersion have been avoided at an earlier stage in the OWMC site selection process, (e.g. near the Niagara Escarpment or the Great Lakes) (ORF, 1983). Thus, none of the candidate sites is expected to experience significantly higher levels of air pollution or increased frequencies of such episodes due to local topographic or meteorological influences. Some potential for wind channelling and effects on atmospheric turbulence have been identified at sites LF4N and PI1N. However, the severity of any effects on air quality is considered minor, and this conclusion has been verified by sensitivity analyses (see Chapter 6). The factor and indicator dealing with restraints to dispersion has therefore been assigned a weighting of 1.

Indicators which address existing air quality are given a somewhat higher weighting of 3. Although the incremental effect on local air quality due to the OWMC facility would be small, the existence of polluting industries in the vicinity of the candidate sites was considered a potential constraint on the future operations of OWMC, should an airshed management programme be introduced for the affected area. This was a particular concern at the sites in Niagara Falls (LF1E and PI27E).

Table 5.4 summarizes the impact indicator weightings and their rationales. As with the risk factors, each factor weighting is the arithmetic mean of the contributing indicator weightings.

5.5 RANKING OF SITING OPTIONS

The siting options were ranked, based on the results of the suitability and weighting evaluations described in previous sections of this chapter. Within each factor or factor grouping, the products of the weights and suitability levels for the contributing indicators were summed, and then dividing by the sum of the indicator weights. These "weighted suitability levels" established the rankings or orders of preference of the siting options by factor and factor grouping.

Table 5.5 summarizes results for factors concerned with human health risk. It shows indicator weights, suitability levels and weighted suitability levels for each indicator/siting option combination, as well as the weighted suitability levels by factor and for the factor grouping as a whole. Table 5.6 is a corresponding summary for factors concerned with general air quality impacts including atmospheric dispersion conditions. The orders of preference of the siting options are illustrated in Figures 5.1 and 5.2 for the risk and impact factors, respectively.

The results of the numerical analysis for the risk factors indicated that LF3C in West Lincoln is the preferred siting option, followed by LF9C, also in West Lincoln, and LF1E in Niagara Falls. The West Lincoln sites are in a comparatively sparsely populated area, and thus would result in the lowest population risks due to direct inhalation of emissions. It should be noted in this regard that the generic risk assessment (Environ, 1985) indicates that the direct inhalation pathways are of significantly greater concern than the indirect pathways (by ingestion of cistern or pond water and consumption of crops and livestock).

TABLE 5.4: Basis for Impact Indicator Weightings

Factor	Indicator	Weighting	Reason for Weighting and Comments
I1 Restraints to Dispersion	1. Local modifications to dispersion climatology	1	• minimal restraints to dispersion for all sites (addressed in previous site selection stages) • any minor restraints can be mitigated through design or operations
I2 Existing and Anticipated Air Quality	1. Existing air quality	3	• moderate concern; within criteria at all sites (except particulates) • insufficient capacity to accomodate new source could be a restraint • mitigation of existing sources outside control of OWMC
	2. Existing short term air quality	3	• occurrence or likelihood of levels approaching or exceeding standards due to existing sources may result in restraints on OWMC facility • effects localized, but may be both frequent and severe • mitigation of existing sources outside control of OWMC
	3. Estimated effect on air quality - incinerator emissions	1	• incremental effects attributable to stack are minimal (1% or less)
	4. Estimated effect on air quality - fugitive emissions	2	• incremental effects attributable to fugitive emissions are small (10% or less) • increment most significant for TSP; however, good possibility of mitigation, especially for landfill

TABLE S.5: Weighted Suitability Levels For The Siting Options - Risk Factors

FACTOR GROUPING	FACTORS	INDICATORS	INDICATOR WEIGHT	LF3C SUIT. LEVEL	LF3C S.L. X WT	LF9C SUIT. LEVEL	LF9C S.L. X WT	LF1E SUIT. LEVEL	LF1E S.L. X WT	LF1E/PI27E SUIT. LEVEL	LF1E/PI27E S.L. X WT	LF4N/PI1N SUIT. LEVEL	LF4N/PI1N S.L. X WT	LF4N/PI1JN SUIT. LEVEL	LF4N/PI1JN S.L. X WT
RISK-Air Quality	R1 Risks from Direct Inhalation of Emissions - Chronic	1 Relative population exposure - incinerator stack emissions	5	-1.0	-5.0	-1.3	-6.3	-3.8	-18.8	-4.5	-22.5	-2.8	-13.8	-5.0	-25.0
		2 Relative population exposure - fugitive emissions	5	-1.0	-5.0	-1.3	-6.5	-1.9	-9.5	-5.0	-25.0	-4.1	-20.5	-3.0	-15.0
		3 Relative future population exposure - incinerator stack emissions	5	-1.0	-5.0	-1.2	-6.0	-2.6	-13.0	-3.0	-15.0	-4.0	-20.0	-5.0	-25.0
		4 Relative future population exposure - fugitive emissions	5	-1.0	-5.0	-1.2	-6.0	-1.2	-6.0	-5.0	-25.0	-3.5	-17.5	-3.9	-19.5
	R2 Risks from Direct Inhalation of Emissions - Acute	1 Topographic features on or around site	1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-5.0	-5.0	-5.0	-5.0
		2 Relative population exposure -upset emissions from incinerator stack	3	-1.0	-3.0	-1.0	-3.0	-1.4	-4.2	-5.0	-15.0	-2.9	-8.7	-1.0	-3.0
		3 Relative population exposure -upset emissions from low elevat'n sources	5	-2.4	-12.0	-2.6	-13.0	-4.5	-22.5	-1.8	-9.0	-2.5	-12.5	-5.0	-25.0
		4 Relative future population exposure - upset emissions from incin stack	3	-1.0	-3.0	-1.1	-3.3	-1.6	-4.8	-5.0	-15.0	-2.6	-7.8	-1.7	-5.1
		5 Relative future population exposure - upset emissions from low elev sources	5	-2.1	-10.5	-2.2	-11.0	-3.4	-17.0	-1.0	-5.0	-2.5	-12.5	-5.0	-25.0
		6 Distribution of community facilities	5	-1.6	-8.0	-2.1	-10.5	-1.0	-5.0	-2.7	-13.5	-5.0	-25.0	-1.6	-8.0
	R3 Risks from Ingestion of Cistern and Pond Water	1 Relative exposure from cistern and pond water - incin stack emissions	3	-3.2	-9.6	-1.9	-5.7	-5.0	-15.0	-1.0	-3.0	-1.4	-4.2	-1.4	-4.2
		2 Relative exposure from cistern and pond water - fugitive emissions	3	-1.3	-3.9	-1.1	-3.3	-5.0	-15.0	-1.0	-3.0	-1.3	-3.9	-2.1	-6.3
	R4 Risks from Consumption of Crops and Livestock	1 Relative sensitive crop exposures - incinerator stack emissions	3	-5.0	-15.0	-4.5	-13.5	-1.3	-3.9	-1.0	-3.0	-2.0	-6.0	-1.8	-5.4
		2 Relative sensitive crop exposures - fugitive emissions	3	-2.4	-7.2	-2.9	-8.7	-1.4	-4.2	-1.0	-3.0	-4.1	-12.3	-4.6	-13.8
		3 Relative sensitive livestock exposures - incinerator stack emissions	3	-5.0	-15.0	-4.1	-12.3	-1.1	-3.3	-1.0	-3.0	-1.3	-3.9	-1.2	-3.6
		4 Relative sensitive livestock exposures - fugitive emissions	1	-2.4	-2.4	-5.0	-5.0	-1.6	-1.6	-1.0	-1.0	-2.0	-2.0	-2.8	-2.8
		5 Relative future sensitive crop exposures - incin stack emissions	3	-5.0	-15.0	-4.5	-13.5	-1.3	-3.9	-1.0	-3.0	-2.1	-6.3	-1.8	-5.4
		6 Relative future sensitive crop exposures - fugitive emissions	3	-2.5	-7.5	-3.0	-9.0	-1.5	-4.5	-1.0	-3.0	-4.1	-12.3	-4.6	-13.8
		7 Relative future sensitive livestock exposures - incin stack emissions	3	-5.0	-15.0	-4.1	-12.3	-1.1	-3.3	-1.0	-3.0	-1.3	-3.9	-1.2	-3.6
		8 Relative future sensitive livestock exposures - fugitive emissions	1	-2.4	-2.4	-5.0	-5.0	-1.7	-1.7	-1.0	-1.0	-2.0	-2.0	-2.8	-2.8

(...Continued)

TABLE S.5: Weighted Suitability Levels For The Siting Options - Risk Factors (...Continued)

FACTORS	MEAN FACTOR WEIGHT	LF3C	LF9C	LF1E	LF1E/PI27E	LF4N/PI1N	LF4N/PI13N
		WT S.L.	WT S.L.	WT S.L.	WT S.L.	WT S.L.	WT S.L.
R1 Risk Direct Inhalation Emissions-Chronic	5.0	-1.0	-1.2	-2.4	-4.4	-3.6	-4.2
R2 Risks Direct Inhalation Emissions-Acute	3.7	-1.7	-1.9	-2.5	-2.7	-3.3	-3.2
R3 Risks Ingestion Cistern/Pond Water	3.0	-2.3	-1.5	-5.0	-1.0	-1.4	-1.8
R4 Risks Consumption Crops & Livestock	2.5	-4.0	-4.0	-1.3	-1.0	-2.4	-2.6
RISK FACTORS	3.4	-2.2	-2.3	-2.3	-2.5	-2.9	-3.2

Note: WT = Weight(ed)
S.L. = Suitability Level
SUIT. = Suitability

TABLE 5.6: Weighted Suitability Levels For The Siting Options - Impact Factors

FACTOR GROUPING	FACTORS	INDICATORS	INDICATOR WEIGHT	LF3C SUIT. LEVEL	LF3C S.L. X WT	LF9C SUIT. LEVEL	LF9C S.L. X WT	LF1E SUIT. LEVEL	LF1E S.L. X WT	LF1E/PI27E SUIT. LEVEL	LF1E/PI27E S.L. X WT	LF4N/PI1N SUIT. LEVEL	LF4N/PI1N S.L. X WT	LF4N/PI13N SUIT. LEVEL	LF4N/PI13N S.L. X WT
ENVIRONMENTAL IMPACT-Air	I1 Restraints to Dispersion	1 Local modifications to dispersion climatology	1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-5.0	-5.0	-3.0	-3.0
	I2 Existing and Anticipated Air Quality	1 Existing air quality	3	-1.5	-4.5	-1.8	-5.4	-4.5	-13.5	-5.0	-15.0	-1.3	-3.9	-1.5	-4.5
		2 Existing short term air quality	3	-1.0	-3.0	-1.0	-3.0	-2.3	-6.9	-5.0	-15.0	-1.0	-3.0	-1.0	-3.0
		3 Estimated effect on air quality - incinerator stack emissions	1	-5.0	-5.0	-5.0	-5.0	-1.0	-1.0	-1.0	-1.0	-5.0	-5.0	-5.0	-5.0
		4 Estimated effect on air quality - fugitive emissions	2	-3.0	-6.0	-3.0	-6.0	-1.0	-2.0	-1.0	-2.0	-5.0	-10.0	-5.0	-10.0

	FACTORS	MEAN FACTOR WEIGHT	LF3C WT	LF3C S.L.	LF9C WT	LF9C S.L.	LF1E WT	LF1E S.L.	LF1E/PI27E WT	LF1E/PI27E S.L.	LF4N/PI1N WT	LF4N/PI1N S.L.	LF4N/PI13N WT	LF4N/PI13N S.L.
WEIGHTED SUITABILITY LEVELS	I1 Restraints to Dispersion	1.0		-1.0		-1.0		-1.0		-1.0		-5.0		-3.0
	I2 Existing and Anticipated Air Quality	2.3		-2.1		-2.2		-2.6		-3.7		-2.4		-2.5
	IMPACT FACTORS	1.7		-2.0		-2.0		-2.4		-3.4		-2.7		-2.6

Note: WT = Weight(ed)
S.L. = Suitability Level
SUIT. = Suitability

Weighted Suitability Level	Factor				
	R1 Direct Inhalation - Chronic	R2 Direct Inhalation - Acute	R3 Ingestion Cisterns/Ponds	R4 Consumption Crops and Livestock	All Risk Factors
-1.0 (most preferred)	LF3C LF9C		LF1E/PI27E LF4N/PI1N LF9C	LF1E/PI27E LF1E	
-2.0		LF3C LF9C	LF4N/PI13N		LF3C
	LF1E		LF3C	LF4N/PI1N	LF1E LF9C
		LF1E		LF4N/PI13N	LF1E/PI27E
		LF1E/PI27E			
-3.0					LF4N/PI1N
		LF4N/PI13N			LF4N/PI13N
		LF4N/PI1N			
	LF4N/PI1N				
-4.0				LF3C LF9C	
	LF4N/PI13N				
	LF1E/PI27E				
-5.0 (least preferred)			LF1E		

Figure 5.1: Order of Preference of Siting Options - Risk Factors

Weighted Suitability Level	Factor		
	I1 Restraints to Dispersion	I2 Existing and Anticipated Air Quality	All Impact Factors
-1.0 (most preferred)	3C 9C 1E 1E/27E		
-2.0		LF3C LF9C	LF3C LF9C
		LF4N/PI1N	LF1E
		LF1E LF4N/PI13N	LF4N/PI13N
			LF4N/PI1N
-3.0	LF4N/PI13N		
			LF1E/PI27E
		LF1E/PI27E	
-4.0			
-5.0 (least preferred)	LF4N/PI1N		

Figure 5.2: Order of Preference of Siting Options - Impact Factors

Although the impact factors are considered less important than the risk factors, the West Lincoln sites (LF3C and LF9C) are equally preferred in terms of general air quality impacts and atmospheric dispersion conditions.

6. SENSITIVITY ANALYSES

6.1 INTRODUCTION

In the process of determining suitability levels for the siting options and weightings for the site selection factors and indicators, some subjective decisions have been made, based on professional judgement. In some cases alternative interpretations have the potential to significantly alter the order of preference of the siting options. Therefore, the effects of such alternatives have been tested in a series of sensitivity analyses described in this chapter.

6.2 ALTERNATIVE WEIGHTING OF RISK INDICATORS

In the previous chapter of this report, weights were assigned to indicators on a linear scale from 1 (least significant) to 5 (most significant). For those indicators concerned with health risks, this was based, in part, on the results of the generic risk assessment (Environ, 1985). The results for chronic exposures are expressed as maximum individual cancer risks ranging from 1×10^{-6} down to 5×10^{-11}, depending on the source of emissions (fugitive or incinerator) and the pathway to man (direct inhalation, ingestion of cistern and pond water, and consumption of crops and livestock). The indicator with the highest associated risk of 1×10^{-6} (relative population exposure - fugitive emissions) was assigned a weight of 5, while the indicator with the lowest associated risk of 5×10^{-11} (relative sensitive livestock exposure - fugitive emissions) was assigned a weight of 1.

In view of the relative magnitudes of the risks, a possible alternative weighting scheme is a logarithmic one, in which the indicator with the lowest risk is given a weight of 1 and the indicator with the highest risk (a risk about four orders of magnitude greater) is given a weight of 10,000. This scheme has been adopted in the sensitivity analysis for all indicators concerned with chronic exposures.

In the case of those indicators involving acute exposure by direct inhalation, a similar approach has been taken in the sensitivity analysis. Indicators referring to upset emissions from the incinerator stack have been assigned a weight of 10 000 (lowest adjusted margin of safety of 0.06, see Table 5.2), and those referring to upset or accidental emissions from low elevation sources have also been assigned a weight of 10 000 (lowest adjusted margin of safety of the same order as for incinerator stack emissions, i.e., 0.02). Note that the highest weight has been chosen to correspond to the highest weight assigned to indicators involving chronic exposures. As well, the indicator referring to the distribution of community facilities is given the highest weight, as before. The only indicator which was assessed qualitatively, i.e., topographic features on or around the site, was given a weight of 1, since it is considered among the least significant of all risk indicators.

Figure 6.1 shows the order of preference of the siting options using the alternative indicator weighting scheme, compared with the base case presented in Chapter 5. The alternative scheme suggests a more distinct preference for sites LF3C and LF9C than in the base case, for all risk factors. The order of preference among the siting options is essentially unchanged, except that LF1E/PI27E becomes the least preferred option instead of the fourth preference. Considering the individual risk factors, the more significant changes are:

Weighted Suitability Level	Factor									
	R1. Inhalation - Chronic		R2. Inhalation - Acute		R3. Cisterns/Ponds		R4. Crops/Livestock		All Risk Factors	
	Base Case	Alternative Weighting Scheme	Base Case	Alternative Weighting Scheme	Base Case	Alternative Weighting Scheme	Base Case	Alternative Weighting Scheme	Base Case	Alternative Weighting Scheme
-1.0 (most preferred)	LF3C LF9C	LF3C LF9C			LF1E/PI27E LF4N/PI1N LF9C	LF1E/P127E LF4N/PI1N LF4N/PI13N	LF1E/P127E LF1E	LF1E/P127E LF1E LF4N/PI13N		LF3C
			LF3C	LF3C LF9C	LF4N/PI13N	LF9C		LF4N/PI1N		LF9C
-2.0			LF9C						LF3C LF1E LF9C LF1E/PI27E	LF1E
	LF1E	LF1E		LF1E	LF3C		LF4N/PI1N LF4N/PI13N			
			LF1E LF1E/PI27E						LF4N/PI1N LF4N/PI13N	LF4N/PI1N LF4N/PI13N
-3.0				LF4N/PI13N 1E/27E 4N/1N		LF3C				LF1E/PI27E
			LF4N/PI13N LF4N/PI1N							
	LF4N/PI1N	LF4N/PI1N					LF3C LF9C			
-4.0								LF9C		
	LF4N/PI13N LF1E/PI27E	LF4N/PI13N LF1E/PI27E								
					LF1E	LF1E		LF3C		
-5.0 (least preferred)										

Figure 6.1: Order of Preference of Siting Options Showing Sensitivity to Alternative Weighting Scheme - Risk Factors

- under the factor concerned with ingestion of cistern and pond water, the order of LF9C and LF4N/PI13N in the base case (third and fourth preferences, respectively) is reversed

- under the factor concerned with consumption of crops and livestock, LF4N/PI1N and LF4N/PI13N become more suitable, but the order of preference in the base case (third and fourth, respectively) is reversed. LF3C clearly becomes the least suitable option.

6.3 ALTERNATIVE DISPERSION CLIMATOLOGIES

The present study suggests that the population exposure indices due to direct inhalation of emissions are the most critical in determining the preferred siting options. In the case of chronic exposures, the suitability levels of the various options are derived from mathematical dispersion modelling which, in turn, depends on assumed dispersion climatologies, i.e., long-term statistical data on wind and atmospheric stability conditions. As described earlier in this report, these data were derived from observations made at Toronto's Pearson International Airport (for sites north of Lake Ontario), and Mount Hope Airport and St. Catharines Airport (for sites south of Lake Ontario).

Although the dispersion climatologies used are considered to be generally representative of the candidate sites, topographic influences in the immediate vicinity of the Niagara Escarpment at Milton may result in some local variations. Any variations are expected to be small, but would be most significant at sites PI1N and LF4N, which are about 5 km from the escarpment. To test the sensitivity of the order of preference of the siting options to such variations, the dispersion climatologies at these sites were adjusted to simulate, on a conservative basis, several possible topographic effects. The cases tested were:

a) winds were assumed to blow from the SSW, SW and WSW directions 25% of the time each, and 2% of the time from each of the other directions

b) winds were assumed to blow from the SSW, SW and WSW directions 20% of the time each, and 3% of the time from each of the other directions, and

c) atmospheric stability classes were assumed to be one class more unstable than that recorded (class F stabilities became class E, class E became class D, etc., and class A stabilities remained the same).

The first two cases were designed to represent the effects of possible wind channelling through the gap in the escarpment between Rattlesnake Point and Mount Nemo, to the southwest of candidate sites PI1N and LF4N. The third case represents the effects of more intense atmospheric turbulence which could occur at these sites due to the proximity of the escarpment.

A fourth case was also explored in order to assess the effects on the population exposure indices of any errors in the assumed wind direction frequencies at all sites, as follows:

d) winds were assumed to blow from all sixteen wind directions with equal frequencies, i.e., 6.25% of the time.

Each of the above four sensitivity analyses were applied separately. New chronic exposure indices were calculated where applicable, and new suitability levels were assigned to the siting options using the same methodology which was applied to the base case (see Chapter 5). The base case indicator weightings were also used. This resulted in four new orders of preference for the siting options under the affected factor (risks from direct inhalation of emissions - chronic) and under the risk factor grouping. These orders of preference are compared to the base case in Figures 6.2 and 6.3.

Weighted Suitability Level	Base Case	Channelled Winds - Case a)	Channelled Winds - Case b)	More Intense Atmospheric Turbulence - Case c)	Equal Wind Direction Frequencies - Case d)
-1.0 (most preferred)	LF3C LF9C	LF3C LF9C	LF3C LF9C	LF3C LF9C	LF3C LF9C
-2.0	LF1E	LF1E	LF1E	LF1E	LF1E LF1E/PI27E
-3.0	LF4N/PI1N	LF4N/PI13N	LF4N/PI13N	LF4N/PI1N	LF4N/PI1N
-4.0	LF4N/PI13N LF1E/PI27E	LF1E/PI27E LF4N/PI1N	LF1E/PI27E LF4N/PI1N	LF4N/PI13N LF1E/PI27E	
-5.0 (least preferred)					LF4N/PI13N

FIGURE 6.2: Order of Preference of Siting Options Showing Sensitivity to Variations in the Dispersion Climatologies - Risk Factor: Direct Inhalation of Emissions - Chronic

Weighted Suitability Level	Base Case	Channelled Winds - Case a)	Channelled Winds - Case b)	More Intense Atmospheric Turbulence - Case c)	Equal Wind Direction Frequencies - Case d)
-1.0 (most preferred)					
-2.0	LF3C LF1E LF9C LF1E/PI27E	LF3C LF1E IE/27E LF9C	LF3C LF1E IE/27E LF9C	LF3C LF1E LF9C LF1E/PI27E LF4N/PI1N	1E/27E LF1E LF3C LF9C
-3.0	LF4N/PI1N LF4N/PI13N	LF4N/PI13N LF4N/PI1N	4N/13N 4N/1N	LF4N/PI13N	LF4N/PI1N LF4N/PI13N
-4.0					
-5.0 (least preferred)					

FIGURE 6.3: Order of Preference of Siting Options Showing Sensitivity to Variations in the Dispersion Climatologies - All Risk Factors

The results of the sensitivity analyses show a reversal in the order of preference of the two Milton siting options under the extreme wind channelling assumption (LF4N/PI13N becomes fifth in order of preference and LF4N/PI1N becomes last). A significant variation is the greater relative preference for option LF1E/PI27E and, to a lesser degree, LF1E, which would apply if wind direction frequencies were uniform. Under this scenario, there is no longer a prevailing wind direction towards the city of Niagara Falls, thus reducing the population exposure indices due to emissions from facility components, especially when these are located at site PI27E. Other variations from the base case are noted, as follows:

- considering all risk factors, LF1E/PI27E becomes more suitable under cases a) and b) (wind channelling), moving from fourth preference to equal second.
- considering the affected factor alone, LF4N/PI1N becomes the least suitable siting option under cases a) and b) (wind channelling), instead of the fourth preference.
- again considering only the affected factor, LF4N/PI13N becomes the least suitable siting option by a wide margin under case d) (uniform wind direction frequencies), instead of the fifth preference.

6.4 ALTERNATIVE ACUTE EXPOSURE INDICES

The base case analysis dealing with upset or accidental emissions included the derivation of acute exposure indices based on the total population within a 5 km radius of each incinerator site (2 km for low elevation emissions). Populations were counted regardless of direction from the sites, since upset or accidental emissions could correspond with any wind direction.

The variation in the frequencies with which the different wind directions and other meteorological conditions occur suggests that populations at certain directions and distances from the sites would have a higher probability of exposure to harmful concentrations of emissions than others.

The probabilities are complex functions of a large number of parameters and are difficult to predict with satisfactory accuracy. However, one important parameter in this determination would be wind direction, and one might reasonably assume a higher probability of exposure for those living downwind of each site in the directions of the most frequently occurring winds. This sensitivity analysis was based on this assumption, although deliberately exaggerating the influence of wind direction.

Acute exposure indices were recalculated counting only those populations which are downwind of the sites in the direction of six of the sixteen wind directions. These six included the prevailing (most frequent) directions and accounted for approximately 60% of all wind conditions. The wind directions were:

- for sites north of Lake Ontario: N, NNW, NW,WNW, W, and WSW
- for site south of Lake Ontario: S, SSW, SW, WSW, W, and WNW

Community facilities were counted in a similar manner.

The analysis provided an alternative ranking of the siting options under the affected factor (risks from direct inhalation of emission - acute) and under the risk factor grouping, as shown in Figure 6.4. Results of the base case analysis are also given in this Figure.

There is no significant affect on the order of preference although there is a greater relative preference for option LF1E, at the expense of LF9C, as follows:

- considering the affected factor alone, LF1E moves from third preference to equal first with LF3C, and LF9C moves from second to third.
- considering all risk factors, LF1E moves from equal second preference to equal first, and LF9C moves from equal second to third.

Weighted Suitability Level	Factor: Risks from Direct Inhalation of Emissions - Acute		All Risk Factors	
	Base Case	Alternative Case	Base Case	Alternative Case
-1.0 (most preferred)				
	LF3C	LF3C LF1E		
-2.0	LF9C			
		LF9C	LF3C	LF3C LF1E
			LF1E LF9C	LF9C
	LF1E	LF1E/PI27E	LF1E/PI27E	LF1E/PI27E
	LF1E/PI27E			
-3.0			LF4N/PI1N	
	LF4N/PI13N	LF4N/PI13N	LF4N/PI13N	4N/1N 4N/13N
	LF4N/PI1N			
		LF4N/PI1N		
-4.0				
-5.0 (least preferred)				

FIGURE 6.4: Order of Preference of Siting Options Showing Sensitivity to Alternative Acute Exposure Indices

7. CONCLUSIONS AND RECOMMENDATIONS

The major conclusions and recommendations resulting from this study are:

a) All siting options are considered acceptable from the standpoint of air quality and atmospheric dispersion.

b) An analysis was undertaken to determine the preferred locations for the physical/chemical treatment plant for the three partially integrated siting options. Site LF4N was considered more suitable for the two Milton siting options, and there was no clear preference for either PI27E or LF1E at Niagara Falls, from an air quality and atmospheric dispersion perspective.

c) From the detailed comparative evaluation of the candidate siting options based on risk factors, LF3C in West Lincoln is the most preferred option. LF9C, also in West Lincoln and LF1E, in Niagara Falls, rank equally as the second most preferred siting options. Based on impact factors, LF3C and LF9C are the most preferred options. Overall, the preference is for the West Lincoln sites.

d) Sensitivity analyses were carried out where it was thought that variations in local dispersion climatologies, alternative acute exposure indices or alternative risk indicator weightings could have an impact on siting option preference. The results do not change the overall preference for the West Lincoln sites.

e) Although the sensitivity analysis has shown that possible alternative dispersion climatologies would not change the preference for the site to be in West Lincoln, it is recommended that site-specific dispersion data be collected at the preferred site, and that further dispersion modelling of emissions be carried out using such data.

f) Studies to date have shown that the impacts of expected emissions from the facility on air quality will be minor to negligible, and well within applicable standards and guidelines. Since these impacts are subject to change as refinements to the design of the facility progress, it is recommended that the implications of any significant design changes on the results of this study be reviewed.

g) Health risks due to consumption of crops and livestock have been shown by the generic risk assessment to be minimal and well below levels considered acceptable. However, further work is recommended to refine the data on those agricultural products which would be most significant in transmitting emissions to humans. This will allow the sensitive crop and livestock exposure indices calculated in this study to be refined to more accurately reflect the comparative risks to populations consuming these products between siting options. It should be noted, however, that the overall preference for options LF3C and LF9C should not be affected by any reassessment, since they are already the least preferred sites under this factor.

h) The documentation of the existing air quality has been based on the best data available at the time of writing of this report. However, conditions at the preferred site should be validated and investigated in greater detail through an on-site monitoring programme.

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APPENDIX A

SUMMARY SHEETS:

RISK INDICATORS

FACTOR: R1. RISKS FROM DIRECT INHALATION OF EMISSIONS - CHRONIC

INDICATOR:

(1) RELATIVE POPULATION EXPOSURE - INCINERATOR STACK EMISSIONS

DEFINITION:

The relative population risk due to direct inhalation of long term incinerator stack emissions.

RATIONALE/SIGNIFICANCE:

Annual average concentration isopleths, based on unit stack emissions, are combined with population data to derive a population exposure index, covering the area of influence of the incinerator stack emissions. Indices indicate, on a comparative basis, the relative population risks associated with each site.

SOURCES OF INFORMATION

Unit emission annual concentration isopleths (see Chapter 3)

Population data (IER)

STUDY AREA:

20 km radius about each incinerator site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not based on emission quantities. Values of indices have no biological or physical significance. Dispersion model limitations (see Chapter 3).

FACTOR: R1. RISK FROM DIRECT INHALATION OF EMISSIONS-CHRONIC

INDICATOR:

(2) RELATIVE POPULATION EXPOSURE - FUGITIVE EMISSIONS

DEFINITION:

The relative population risk due to direct inhalation of long term fugitive emissions.

RATIONALE/SIGNIFICANCE:

Annual average concentration isopleths, based on unit fugitive emissions, are combined with population data to derive a population exposure index, covering the area of influence of the fugitive emissions. Indices indicate, on a comparative basis, the relative population risk associated with each site.

SOURCES OF INFORMATION:

Unit emission concentration isopleths (see Chapter 3)

Population data (IER)

Factor::: AREA:

5 km radius about each site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not based on emission quantities. Values of indices have no biological or physical significance. Dispersion model limitations (see Chapter 3).

FACTOR: R1. RISKS FROM DIRECT INHALATION OF EMISSIONS - CHRONIC

INDICATOR:

(3) RELATIVE FUTURE POPULATION EXPOSURE - INCINERATOR STACK EMISSIONS

DEFINITION:

The relative population risk due to direct inhalation of long-term incinerator stack emissions at year 2000.

RATIONALE/SIGNIFICANCE:

Annual average concentration isopleths, based on unit stack emissions, are combined with population data (projected to year 2000) to derive a population exposure index covering the area of influence of the incinerator. Indices indicate, on a comparative basis, the relative population risks associated with each site.

SOURCES OF INFORMATION

Unit emission concentration isopleths (see Chapter 3)

Future population estimates (Leon Kentridge Associates Ltd.)

STUDY AREA:

20 km radius about each incinerator site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not based on emission quantities. Values of indices have no biological or physical significance. Dispersion model limitations (see Chapter 3). Uncertainties in future population estimates.

FACTOR: R1. RISKS FROM DIRECT INHALATION OF EMISSIONS - CHRONIC

INDICATOR

(4) RELATIVE FUTURE POPULATION EXPOSURE - FUGITIVE EMISSIONS

DEFINITION:

The relative population risk due to direct inhalation of long-term fugitive emissions at year 2000.

RATIONALE/SIGNIFICANCE:

Annual average concentration isopleths, based on unit fugitive emissions, are combined with future population data to derive a population exposure index, covering the area of influence of the fugitive emissions. Indices indicate, on a comparative basis, the relative future population risks associated with each site.

SOURCES OF INFORMATION:

Unit emission concentration isopleths (see Chapter 3)

Future population estimates (Leon Kentridge Associates Ltd.)

STUDY AREA:

5 km radius about each site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not dependent on emission quantities. Values of indices have no biological or physical significance. Dispersion model limitations (see Chapter 3). Uncertainties associated with future population estimates.

FACTOR: R2. RISKS FROM DIRECT INHALATION OF EMISSIONS - ACUTE

INDICATOR

(1) TOPOGRAPHIC FEATURES ON OR AROUND SITE

DEFINITION

Effects of topography on dispersion, both on-site and in the immediate vicinity of the site.

RATIONALE/SIGNIFICANCE:

Some small scale topographic features may be a factor in the event of an accidental spill or release, by channelling or trapping pollutants, e.g. in the case of a heavy vapour release. Higher concentrations can be expected in these situations than would be expected at sites without such topographic features.

SOURCES OF INFORMATION:

Topographic maps (1:10,000)

STUDY AREA:

5 km radius about each site

COMMENTS/ASSUMPTIONS/LIMITATIONS

Assessment qualitative only.

FACTOR: R2. RISKS FROM DIRECT INHALATION OF EMISSIONS - ACUTE

INDICATOR

(2) RELATIVE POPULATION EXPOSURE - UPSET EMISSIONS FROM INCINERATOR STACK

DEFINITION:

Population potentially at risk due to upset emissions from incinerator stack.

RATIONALE/SIGNIFICANCE:

Considers those residents most likely to be exposed to high ground level concentrations in the event of an upset emission.

SOURCES OF INFORMATION:

Population data (IER)

STUDY AREA:

5 km radius about each incinerator site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Assessment not dependent on emission quantities.

FACTOR: R2. RISKS FROM DIRECT INHALATION OF EMISSIONS - ACUTE

INDICATOR

(3) RELATIVE POPULATION EXPOSURE - UPSET EMISSIONS FROM LOW ELEVATION SOURCES

DEFINITION:

Population potentially at risk due to low elevation upset or accidental emissions.

RATIONALE/SIGNIFICANCE:

Considers those residents most likely to be exposed to high ground level concentrations in the event of an upset emission.

SOURCES OF INFORMATION:

Population data (IER).

STUDY AREA:

2 km radius about each site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Assessment not dependent on emission quantities.

FACTOR: R2. RISKS FROM DIRECT INHALATION OF EMISSIONS - ACUTE

INDICATOR

(4) RELATIVE FUTURE POPULATION EXPOSURE - UPSET EMISSIONS FROM INCINERATOR STACK

DEFINITION:

Population potentially at risk due to upset emissions from incinerator stack at year 2000.

RATIONALE/SIGNIFICANCE:

Considers those future residents most likely to be exposed to high ground level concentrations in the event of an upset emission.

SOURCES OF INFORMATION:

Future population estimates (Leon Kentridge Associates Ltd)

STUDY AREA:

5 km radius about each incinerator site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Assessment not dependent on emission quantities. Uncertainties associated with future population estimates.

FACTOR: R2. RISKS FROM DIRECT INHALATION OF EMISSIONS - ACUTE

INDICATOR

(5) RELATIVE FUTURE POPULATION EXPOSURE - UPSET EMISSIONS FROM LOW ELEVATION SOURCES

DEFINITION:

Population potentially at risk due to low elevation upset or accidental emissions at year 2000.

RATIONALE/SIGNIFICANCE:

Considers those future residents most likely to be exposed to high ground-level concentrations in the event of an upset emission.

SOURCES OF INFORMATION:

Future population estimates (Leon Kentridge Associates Ltd)

STUDY AREA:

2 km radius about each site

COMMENTS/ASSUMPTIONS/LIMITATIONS

Assessment not dependent on emission quantities. Uncertainties associated with future population estimates.

FACTOR: R2. RISKS FROM DIRECT INHALATION OF EMISSIONS - ACUTE

INDICATOR

(6) DISTRIBUTION OF COMMUNITY FACILITIES

DEFINITION:

Community facilities potentially at risk due to upset or accidental emissions. Includes hospitals, nursing homes, elementary schools, day-care centres and childrens' camps..

RATIONALE/SIGNIFICANCE:

In the case of upset or accidental emissions, additional risks could be derived from temporary concentrations of sensitive populations in the site vicinity.

SOURCES OF INFORMATION

Locations and numbers of community facilities (IER)

STUDY AREA

5 km radius about each site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Assessment not dependent on emission quantities.

FACTOR: R3. RISKS FROM INGESTION OF CISTERN AND SURFACE WATER

INDICATOR

(1) RELATIVE EXPOSURE FROM CISTERN AND SURFACE WATER - INCINERATOR STACK EMISSIONS

DEFINITION:

Relative population risk due to ingestion of cistern and pond water potentially exposed to incinerator stack emissions.

RATIONALE/SIGNIFICANCE:

Annual average concentration isopleths, based on unit stack emissions, are combined with cistern and pond data to derive an exposure index. Indices show, an a comparative basis, the relative population risk associated with each site.

SOURCES OF INFORMATION:

Unit annual stack emission concentration isopleths (see Chapter 3). Distribution of cisterns and ponds used as potable water supplies. (Gartner Lee Associates)

STUDY AREA:

20 km radius about each site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not based on emission quantities. Values of indices have no biological or physical significance. Dispersion model limitations (Chapter 3). Available data limited to 5 km radius about each site. Data not considered reliable between 2 and 5 km.

FACTOR: R3. RISKS FROM INGESTION OF CISTERN AND SURFACE WATER

INDICATOR

(2) RELATIVE EXPOSURE FROM CISTERN AND POND WATER - FUGITIVE EMISSIONS

DEFINITION: Relative population risk due to ingestion of cistern and pond water potentially exposed to fugitive emissions.

RATIONALE/SIGNIFICANCE

Annual average concentration isopleths, based on unit stack emissions, are combined with cistern and pond data to derive an exposure index. Indices show, an a comparative basis, the relative population risk associated with each site.

SOURCES OF INFORMATION:

Distribution of cisterns and ponds used as potable water supplies (Gartner Lee Associates). Unit annual fugitive emission concentration isopleths (see Chapter 3).

STUDY AREA:

5 km radius about each site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not based on emission quantities. Values of indices have no biological or physical significance. Dispersion model limitations (Chapter 3). Data not considered reliable between 2 and 5 km.

FACTOR: R4. RISKS FROM CONSUMPTION OF CROPS AND LIVESTOCK

INDICATOR

(1) RELATIVE SENSITIVE CROP EXPOSURES - INCINERATOR STACK EMISSIONS

DEFINITION:

Relative population risk due to consumption of sensitive crops potentially exposed to incinerator stack emissions.

RATIONALE/SIGNIFICANCE:

Annual average concentration isopleths, based on unit stack emissions, are combined with crop sensitivity data to derive a crop exposure index, covering the area of influence of the incinerator stack emissions. Indices show on a comparative basis, the relative population risk associated with each site.

SOURCES OF INFORMATION:

Unit annual stack emission concentration isopleths (see Ch. 3)

Sensitive crop data (Ecologistics)

STUDY AREA:

20 km radius about each incinerator site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not based on emission quantities. Value of indices have no biological or physical significance. Dispersion model limitations (see Chapter 3). In current analysis, total weight of all edible crops produced per annum was used in absence of data on quantities of sensitive crops of most significance in transmitting emissions to man.

FACTOR: R4. RISKS FROM CONSUMPTION OF CROPS AND LIVESTOCK

INDICATOR

(2) RELATIVE SENSITIVE CROP EXPOSURES - FUGITIVE EMISSIONS

DEFINITION:

Relative population risk due to consumption of sensitive crops potentially exposed to fugitive emissions.

RATIONALE/SIGNIFICANCE:

Annual average concentration isopleths, based on unit fugitive emissions from all facility components, are combined with crop sensitivity data to derive a crop exposure index. Indices show, on a comparative basis, the relative population risk associated with each site.

SOURCES OF INFORMATION:

Unit annual fugitive emission concentration isopleths (see Chapter 3)

Sensitive crop data (Ecologistics)

STUDY AREA:

5 km radius about each site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not based on emisssion quantities. Values of indices have no biological or physical significance. Dispersion model limitations (see Chapter 3). In current analysis, total weight of all edible crops produced per annum was used in absence of data on quantities of sensitive crops of most significance in transmitting emissions to man.

FACTOR: R4. RISKS FROM CONSUMPTION OF CROPS AND LIVESTOCK

INDICATOR

(3) RELATIVE SENSITIVE LIVESTOCK EXPOSURES - INCINERATOR STACK EMISSIONS

DEFINITION:

Relative population risk due to consumption of sensitive livestock potentially exposed to incinerator stack emissions.

RATIONALE/SIGNIFICANCE:

Annual average concentration isopleths, based on unit stack emissions, are combined with livestock sensitivity data to derive a livestock exposure index, covering the area of influence of the incinerator stack emissions. Indices show, on a comparative basis, the relative population risk associated with each site.

SOURCES OF INFORMATION:

Unit annual stack emission concentration isopleths (see Ch. 3)
Sensitive livestock data (Ecologistics)

STUDY AREA:

20 km radius about each incinerator site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not based on emission quantities. Values of indices have no biological or physical significance. Dispersion model limitations (see Chapter 3). In current analysis, total weight of all edible livestock produced per annum was used in absence of data on quantities of sensitive livestock of most significance in transmitting emissions to man.

FACTOR: R4. RISKS FROM CONSUMPTION OF CROPS AND LIVESTOCK

INDICATOR

(4) RELATIVE SENSITIVE LIVESTOCK EXPOSURE - FUGITIVE EMISSIONS

DEFINITION:

Relative population risk due to consumption of sensitive livestock potentially exposed to fugitive emissions.

RATIONALE/SIGNIFICANCE:

Annual average concentration isopleths, based on unit stack emissions are combined with livestock sensitivity data to derive a livestock exposure index. Indices show, on a comparative basis, the relative population risk associated with each site.

SOURCES OF INFORMATION:

Unit annual fugitive emission concentration isopleths (see Chapter 3)

Sensitive livestock data (Ecologistics)

STUDY AREA:

5 km radius about each site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not based on emission quantities. Values of indices have no biological or physical significance. Dispersion model limitations (see Chapter 3). In current analysis, total weight of all edible livestock produced per annum was used in absence of data on quantities of sensitive livestock of most significance in transmitting emissions to man.

FACTOR: R4. RISKS FROM CONSUMPTION OF CROPS AND LIVESTOCK

INDICATOR

(5) RELATIVE FUTURE SENSITIVE CROP EXPOSURES - INCINERATOR STACK EMISSIONS

DEFINITION:

Relative population risk due to consumption of sensitive crops potentially exposed to incinerator stack emissions (crops projected to year 2000).

RATIONALE/SIGNIFICANCE:

Annual average concentrations isopleths, based on unit stack emissions, are combined with future crop sensitivity data to derive a crop exposure index, covering the area of influence of the incinerator stack emissions. Indices show, on a comparative bais, the relative population risk associated with each site.

SOURCES OF INFORMATION:

Unit annual stack emission concentration isopleths (see Ch. 3)
Future sensitive crop data (Ecologistics)

STUDY AREA:

20 km radius about each incinerator site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not based on emission quantities. Values of indices have no biological or physical significance. Dispersion model limitations (see Chapter 3). In current analysis, total weight of all edible crops was used in absence of data on quantities of sensitive crops of most significance in transmitting emissions to man.

FACTOR: R4. RISKS FROM CONSUMPTION OF CROPS AND LIVESTOCK

INDICATOR

(6) RELATIVE FUTURE SENSITIVE CROP EXPOSURES - FUGITIVE EMISSIONS

DEFINITION:

Relative population risk due to consumption of sensitive crops potentially exposed to fugitive emissions (crops projected to year 2000).

RATIONALE/SIGNIFICANCE:

Annual average concentration isopleths, based on unit fugitive emissions, are combined with future crop sensitivity data to derive a crop exposure index, covering the area of influence of fugitive emissions. Indices show, on a comparative basis, the relative population risk associated with each site.

SOURCES OF INFORMATION:

Unit annual fugitive emission concentration isopleths (see Chapter 3)

Future sensitive crop data (Ecologistics)

STUDY AREA:

5 km radius about each site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not based on emission quantities. Values of indices have no biological or physical significance. Dispersion model limitations (see Chapter 3). In current analysis, total weight of all edible crops was used in absence of data on quantities of sensitive crops of most significance in transmitting emissions to man.

FACTOR: R4. RISKS FROM CONSUMPTION OF CROPS AND LIVESTOCK

INDICATOR

(7) RELATIVE FUTURE SENSITIVE LIVESTOCK EXPOSURES - INCINERATOR STACK EMISSIONS

DEFINITION:

Relative population risk due to consumption of sensitive livestock potentially exposed to incinerator stack emissions (livestock projected to year 2000).

RATIONALE/SIGNIFICANCE:

Annual average concentration isopleths, based on unit stack emissions, are combined with future livestock sensitivity data to derive a livestock exposure index, covering the area of influence of the incinerator stack emissions. Indices show, on a comparative basis, the relative population risk associated with each site.

SOURCES OF INFORMATION:

Unit annual stack emission concentration isopleths (see Ch. 3)
Future sensitive livestock data (Ecologistics)

STUDY AREA:

20 km radius about each incinerator site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not based on emission quantities. Values of indices have no biological or physical significance. Dispersion model limitations (see Chapter 3). In current analysis, total weight of all edible livestock was used in absence of data on quantities of sensitive livestock of most significance in transmitting emissions to man.

FACTOR: R4. RISKS FROM CONSUMPTION OF CROPS AND LIVESTOCK

INDICATOR

(8) RELATIVE FUTURE SENSITIVE LIVESTOCK EXPOSURES - FUGITIVE EMISSIONS

DEFINITION:

Relative population risk due to consumption of sensitive livestock potentially exposed to fugitive emissions (livestock projected to year 2000).

RATIONALE/SIGNIFICANCE:

Annual average concentration isopleths, based on unit fugitive emissions are combined with future livestock sensitivity data to derive a livestock exposure index, covering the area of influence of the fugitive emissions. The relative risks to future livestock associated with each site are compared.

SOURCES OF INFORMATION:

Unit annual fugitive emission concentration isopleths
Future livestock dollar values (Ecologistics)

STUDY AREA:

5 km radius about each site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Comparative assessment only - not based on emission quantities. Values of indices have no biological or physical significance. Dispersion model limitations (see Chapter 3). In current analysis, total weight of all edible livestock was used in absence of data on quantities of sensitive livestock of most significance in transmitting emissions to man.

APPENDIX B

SUMMARY SHEETS

IMPACT INDICATORS

FACTOR: I1. RESTRAINTS TO DISPERSION

INDICATOR

(1) LOCAL MODIFICATIONS TO DISPERSION CLIMATOLOGY

DEFINITION:

Effects of local topography on dispersion climatology.

RATIONALE/SIGNIFICANCE:

Dispersion of emissions may be modified by local features influencing wind patterns, turbulence and stability conditions at a site. Higher concentrations of emissions downwind of facility may occur as a result of such modifications.

SOURCES OF INFORMATION:

Topographic maps (1:50,000)

STUDY AREA:

20 km radius about each incinerator site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Assessment qualitative only. Refers to local phenomena not included in the long-term modelling described in Chapter 3.

FACTOR: I2. EXISTING AND ANTICIPATED AIR QUALITY

INDICATOR

(1) EXISTING AIR QUALITY

DEFINITION:

Existing annual averaged levels of SO_2, NO_x, TSP and THC and their relationship to ambient air quality criteria.

RATIONALE/SIGNIFICANCE:

Areas where air quality criteria are approached or exceeded should generally be avoided. Relatively high existing levels of airborne pollutants may constrain OWMC operations, even though increment due to proposed facility would be small.

SOURCES OF INFORMATION:

Annual concentration isopleths for Golden Horseshoe (ORF, 1984)

Regulation 296 (Environmental Protection Act of Ontario)

Measured concentrations from the Ministry of the Environment's air quality monitoring network

STUDY AREA

20 km radius about each incinerator site, and 5 km radius about all sites

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Based on four criteria pollutants only, but considered representative of general air quality. Dispersion model limitations in predictions of existing ambient air quality levels. (see ORF, 1984)

FACTOR: I2. EXISTING AND ANTICIPATED AIR QUALITY

INDICATOR

(2) EXISTING SHORT TERM AIR QUALITY

DEFINITION:

Significant local point sources of air emissions and resulting maximum short-term (1/2-hour) ambient air concentrations.

RATIONALE/SIGNIFICANCE:

Existing local sources may produce relatively high concentrations of certain contaminants over a short time period. This may limit the capacity of the airshed to accommodate similar emissions from the OWMC facility under certain meteorological conditions. May result in constraints on OWMC operations, even though increment due to proposed facility would be small.

SOURCES OF INFORMATION:

Ministry of the Environment inventory of emission sources
Regulation 308, Environmental Protection Act of Ontario

STUDY AREA

5 km radius about each incinerator site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Emissions data limited to information in the MOE inventory. Dispersion model limitations - projection of maximum ambient air concentrations based on Regulation 308. For purposes of analysis, concentrations from more than one source in a given site vicinity were assumed to be additive.

FACTOR: I2. EXISTING AND ANTICIPATED AIR QUALITY

INDICATOR

(3) ESTIMATED EFFECT ON AIR QUALITY - INCINERATOR STACK EMISSIONS

DEFINITION:

Projected maximum annual increments of SO_2, NO_x, TSP and THC concentrations due to incinerator emissions.

RATIONALE/SIGNIFICANCE:

Desireable to minimize degradation in local air quality.

SOURCES OF INFORMATION:

Existing air quality data for Golden Horseshoe (ORF, 1984)
Unit annual stack emission concentration isopleths (see Ch. 3)
Estimated emission rates for OWMC facility (see Table 3.2)

STUDY AREA

20 km radius about all incinerator sites

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Dispersion model limitations (see Chapter 3). Limited to four criteria pollutants. Based on present estimates of incinerator emissions.

FACTOR: I2. EXISTING AND ANTICIPATED AIR QUALITY

INDICATOR

(4) ESTIMATED EFFECT ON AIR QUALITY - FUGITIVE EMISSIONS

DEFINITION:

Projected maximum annual increments of TSP and THC concentrations due to fugitive emissions.

RATIONALE/SIGNIFICANCE:

Desireable to minimize degradation in local air quality.

SOURCES OF INFORMATION:

Existing air quality data for Golden Horseshoe (ORF, 1984)

Unit annual fugitive emission concentration isopleths (see Chapter 3)

Estimated emission rates for OWMC facility (see Table 3.2)

STUDY AREA

5 km radius about each site

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Dispersion model limitations (see Chapter 3). Limited to two criteria pollutants. Based on present estimates of fugitive emissions.

APPENDIX C

DATA MATRICES

FACTOR GROUPING: RISK - Air Quality

FACTOR: R1. Risks from Direct Inhalation of Emissions - Chronic

INDICATORS 1 and 2: Relative Population Exposure - Incinerator Stack and Fugitive Emissions

Site	Population Exposure Index		Suitability Level	
	Incinerator Stack	Fugitive	Incinerator Stack	Fugitive
LF4N	n/a	1787	n/a	-4.9
PI1N	1606	1507	-2.7	-4.1
PI13N	3281	1061	-5.0	-2.8
LF9C	610	470	-1.4	-1.1
LF3C	319	433	-1.0	-1.0
LF1E	2435	699	-3.9	-1.8
PI27E	2889	1808	-4.5	-5.0

FACTOR GROUPING: RISK - Air Quality

FACTOR: R1. Risks from Direct Inhalation of Emissions - Chronic

INDICATORS 3 and 4: Relative Future Population Exposure - Incinerator Stack and Fugitive Emissions

Site	Population Exposure Index		Suitability Level	
	Incinerator Stack	Fugitive	Incinerator Stack	Fugitive
LF4N	n/a	2577	n/a	-3.2
PI1N	4278	2884	-3.9	-3.5
PI13N	5797	3169	-5.0	-3.9
LF9C	610	956	-1.2	-1.2
LF3C	323	794	-1.0	-1.0
LF1E	2440	991	-2.5	-1.2
PI27E	2976	4106	-2.9	-5.0

FACTOR GROUPING: RISK - Air Quality

FACTOR: R2. Risks from Direct Inhalation of Emissions - Acute

INDICATOR 1: Topographic features on or around site

Site	Feature	Suitability Level
LF4N	relatively flat, land gently sloping up towards escarpment	-1.0
PI1N	site relatively flat, Sixteen Mile Creek running east-west just north of site in a depression approx. 20 m (approx. 1.2 km from site centre)	-5.0
PI13N	site relatively flat, Sixteen Mile Creek is in a depression of approx. 25 m (approx. .8 to 2 km from site to the east and south)	-5.0
LF9C	very flat	-1.0
LF3C	very flat - river running approx. 2 km south of site in slight depression (approx. 5 m)	-1.0
LF1E	very flat - Lyons Creek approx. 1.5 km south of site, but not in a depression	-1.0
PI27E	very flat - Welland R. running east-west just north of site, but no noticeable topographic change.	-1.0

FACTOR GROUPING: RISK - Air Quality

FACTOR: R2. Risks from Direct Inhalation of Emissions - Acute

INDICATORS 2 and 3: Relative Population Exposure - Upset Emissions from Incinerator Stack and Low Elevation Sources

Site	Population		Suitability Level	
	Incinerator Stack*	Low Elevation**	Incinerator Stack	Low Elevation
LF4N	n/a	126	n/a	-1.0
PI1N	4552	184	-3.0	-2.5
PI13N	1620	277	-1.1	-5.0
LF9C	1547	185	-1.0	-2.6
LF3C	1489	180	-1.0	-2.4
LF1E	2213	260	-1.5	-4.5
PI27E	7478	156	-5.0	-1.8

* Estimated population within 5 km radius of site

** Estimated population within 2 km radius of site

FACTOR GROUPING: RISK - Air Quality

FACTOR: R2. Risks from Direct Inhalation of Emissions-Acute

INDICATORS 4 and 5: Relative Future Population Exposure - Upset Emissions from Incinerator Stack and Low Elevation Sources

Site	Future Population		Suitability Level	
	Incinerator Stack*	Low Elevation**	Incinerator Stack	Low Elevation
LF4N	n/a	137	n/a	-1.0
PI1N	5875	208	-2.6	-2.6
PI13N	3658	320	-1.7	-5.0
LF9C	2186	192	-1.1	-2.2
LF3C	1904	187	-1.0	-2.1
LF1E	3480	248	-1.6	-3.4
PI27E	11701	138	-5.0	-1.0

* Estimated future population within 5 km radius of site

** Estimated future population within 2 km radius of site

FACTOR GROUPING: RISK - Air Quality

FACTOR: R2. Risks from Direct Inhalation of Emissions - Acute

INDICATOR 6: Distribution of Community Facilities*

Site	Hospitals	Nursing Homes	Elementary Schools	Day Care Centres	Childrens' Camps	Total	Suitability Level
LF4N	1		2	3	2	8	-5.0
PI1N	1		2	3	2	8	-5.0
PI13N			1		1	2	-1.6
LF9C			2	1		3	-2.1
LF3C			1		1	2	-1.6
LF1E			1			1	-1.0
PI27E		1	2	1		4	-2.7

*Facilities within 5 km radius of site.

FACTOR GROUPING: RISK - Air Quality

FACTOR: R3. Risks from Ingestion of Cistern and Pond Water

INDICATOR 1: Relative Exposure from Cistern and Pond Water - Incinerator Stack Emissions

Site	Exposure Index			Suitability Level		
	Cisterns	Ponds	Cisterns and Ponds	Cisterns	Ponds	Cisterns and Ponds
PI1N	0.06	0.13	0.19	-1.0	-2.7	-1.4
PI13N	0.10	0.09	0.19	-1.4	-2.0	-1.4
LF9C	0.14	0.13	0.27	-1.7	-2.7	-1.9
LF3C	0.20	0.25	0.45	-2.3	-5.0	-3.2
LF1E	0.49	0.21	0.70	-5.0	-4.2	-5.0
PI27E	0.09	0.04	0.14	-1.3	-1.0	-1.0

FACTOR GROUPING: RISK - Air Quality

FACTOR: R3. Risks from Ingestion of Cistern and Pond Water

INDICATOR 2: Relative Exposure from Cistern and Pond Water - Fugitive Emissions

Site	Exposure Index			Suitability Level		
	Cisterns	Ponds	Cisterns and Ponds	Cisterns	Ponds	Cisterns and Ponds
LF4N	26.3	35.6	61.8	-2.1	-1.7	-1.5
PI1N	5.7	42.6	48.3	-1.0	-1.9	-1.3
PI13N	56.2	36.8	93.1	-3.7	-1.8	-2.1
LF9C	22.2	19.1	41.2	-1.9	-1.3	-1.1
LF3C	32.9	19.9	52.8	-2.5	-1.3	-1.3
LF1E	80.3	157.4	237.7	-5.0	-5.0	-5.0
PI27E	27.4	7.8	35.2	-2.2	-1.0	-1.0

FACTOR GROUPING: RISK - Air Quality

FACTOR: R4. Risks from Consumption of Crops and Livestock

INDICATORS 1 and 2: Relative Sensitive Crop Exposures - Incinerator Stack and Fugitive Emissions

Site	Crop Exposure Index*		Suitability Level	
	Incinerator Stack	Fugitive	Incinerator Stack	Fugitive
LF4N	n/a	19790392	n/a	-5.0
PI1N	1364401	15864400	-2.0	-4.1
PI13N	1252402	18161846	-1.8	-4.6
LF9C	2520247	10995418	-4.5	-2.9
LF3C	2731774	9148723	-5.0	-2.4
LF1E	1027027	5025001	-1.3	-1.4
PI27E	886475	3154755	-1.0	-1.0

* based on total weight of edible crops produced per annum

FACTOR GROUPING: RISK - Air Quality

FACTOR: R4. Risks from Consumption of Crops and Livestock

INDICATOR 3 and 4: Relative Sensitive Livestock Exposures - Incinerator Stack and Fugitive Emissions

Site	Livestock Exposure Index*		Suitability Level	
	Incinerator Stack	Fugitive	Incinerator Stack	Fugitive
LF4N	n/a	1407213	n/a	-2.3
PI1N	103084	1118742	-1.3	-2.0
PI13N	86226	1914902	-1.2	-2.8
LF9C	437786	4031442	-4.1	-5.0
LF3C	540424	1513674	-5.0	-2.4
LF1E	80100	770971	-1.1	-1.6
PI27E	67665	208591	-1.0	-1.0

* based on total weight of edible livestock produced per annum

FACTOR GROUPING: RISK - Air Quality

FACTOR: R4. Risks from Consumption of Crops and Livestock

INDICATORS 5 and 6: Relative Future Sensitive Crop Exposures - Incinerator Stack and Fugitive Emissions

Site	Crop Exposure Index*		Suitability Level	
	Incinerator Stack	Fugitive	Incinerator Stack	Fugitive
LF4N	n/a	19768672	n/a	-5.0
PI1N	1360077	15791588	-2.1	-4.1
PI13N	1252402	18161846	-1.8	-4.6
LF9C	2518657	10979195	-4.5	-3.0
LF3C	2729523	9129957	-5.0	-2.5
LF1E	997286	4604267	-1.3	-1.5
PI27E	866862	2404460	-1.0	-1.0

* based on total weight of edible crops produced per annum

FACTOR GROUPING: RISK - Air Quality

FACTOR: R4. Risks From Consumption of Crops and Livestock

INDICATORS 7 and 8: Relative Future Livestock Exposures - Stack and Fugitive Emissions

Site	Livestock Exposure Index *		Suitability Level	
	Incinerator Stack	Fugitive	Incinerator Stack	Fugitive
LF4N	n/a	1407213	n/a	-2.3
PI1N	103084	1118742	-1.3	-2.0
PI13N	86226	1914902	-1.2	-2.8
LF9C	437488	4027219	-4.1	-5.0
LF3C	540424	1513674	-5.0	-2.4
LF1E	79848	767340	-1.1	-1.7
PI27E	62965	118837	-1.0	-1.0

* based on total weight of edible livestock produced per annum

FACTOR GROUPING: ENVIRONMENTAL IMPACT - Air Resources

FACTOR: I1. Restraints to Dispersion

INDICATOR 1: Local Modifications to Dispersion Climatology

Site	Modification	Suitability Level
LF4N	Break in escarpment between Rattlesnake Pt. and Mt. Nemo could cause wind channelling at this site. Possible increased levels of turbulence in the wake of the escarpment.	-5.0
PI1N	Break in escarpment between Rattlesnake Pt. and Mt. Nemo could cause wind channelling at this site. Possible increased levels of turbulence in the wake of the escarpment.	-5.0
PI13N	Break in escarpment between Rattlesnake Pt. and Mt. Nemo could cause wind channelling at this site, but less than at PI1N	-3.0
LF9C	No significant modification	-1.0
LF3C	No significant modification	-1.0
LF1E	No significant modification	-1.0
PI27E	No significant modification	-1.0

FACTOR GROUPING: ENVIRONMENTAL IMPACT - Air Resources

FACTOR: I2. Existing and Anticipated Air Quality

INDICATOR 1: Existing Air Quality

Site	SO_2*		NO_x		TSP*		THC	
	Existing Level (ug/m^3)	Relative Level	Existing Level (ug/m^3)	Relative Level	Existing Level (ug/m^3)	Relative Level	Existing Level (ug/m^3)	Relative Level
LF4N	10	0.7	6	0.3	40	0.8	60	0.3
PI1N	11	0.8	7	0.3	40	0.8	70	0.4
PI13N	13	0.9	9	0.4	40	0.8	85	0.5
LF9C	10	0.7	20	0.9	40	0.8	150	0.9
LF3C	8	0.6	17	0.7	40	0.8	130	0.7
LF1E	23	1.6	50	2.2	80	1.5	350	2.0
PI27E	24	1.7	55	2.4	94	1.8	375	2.2
Mean	14		23		53		174	

Site	All Components		Phys/Chem Only	
	Mean Index	Suitability Level	Mean Index	Suitability Level
LF4N	0.5	-1.0	0.6	-1.0
PI1N	0.6	-1.3	0.6	-1.0
PI13N	0.7	-1.5	0.7	-1.3
LF9C	0.8	-1.8	0.9	-1.9
LF3C	0.7	-1.5	0.8	-1.6
LF1E	1.8	-4.5	1.8	-4.4
PI27E	2.0	-5.0	2.0	-5.0

*SO_2 annual criterion 55 ug/m^3
TSP annual criterion 60 ug/m^3

FACTOR GROUPING: ENVIRONMENTAL IMPACT - Air Resources

FACTOR: I2. Existing and Anticipated Air Quality

INDICATOR 2: Existing Short Term Air Quality

Site	Pollutant Loading Index				Suitability Level	
	SO_2	NO_x	TSP	THC	All Components*	Phys./Chem**
LF4N	0	0	0	0	-1.0	-1.0
PI1N	0	0	0	0	-1.0	-1.0
PI13N	0	0	0	0	-1.0	-1.0
LF9C	0	0	0	0	-1.0	-1.0
LF3C	0	0	0	0	-1.0	-1.0
LF1E	1772	244	7684	0	-2.3	-2.2
PI27E	3592	418	26445	0	-5.0	-5.0

* Derived using a total of all four pollutants

** Derived using a total of TSP and THC only

FACTOR GROUPING: ENVIRONMENTAL IMPACT - Air Resources

FACTOR: I2. Existing and Anticipated Air Quality

INDICATOR 3: Estimated Effect on Air Quality - Incinerator Stack Emissions

Site	Existing (ug/m^3)	Incin. Stack (ug/m^3)	I*	Existing (ug/m^3)	Incin. Stack (ug/m^3)	I*
	SO_2			NO_x		
PI1N	11	.04	1.00	7	.04	1.01
PI13N	13	.04	1.00	9	.04	1.01
LF9C	10	.07	1.01	20	.07	1.00
LF3C	8	.07	1.01	17	.07	1.00
LF1E	23	.07	1.00	50	.07	1.00
PI27E	24	.07	1.00	55	.07	1.00

Site	TSP**			THC**			Suitability Level
PI1N	40	.009	1.00	70	.002	1.00	-5.0
PI13N	40	.009	1.00	85	.002	1.00	-5.0
LF9C	40	.013	1.00	150	.004	1.00	-5.0
LF3C	40	.013	1.00	130	.004	1.00	-5.0
LF1E	80	.013	1.00	350	.004	1.00	-1.0
PI27E	94	.013	1.00	375	.004	1.00	-1.0

*$I = \frac{C_n + C_e}{C_e}$ C_e = Existing concentration; C_n = Concentration attributable to facility

** Existing levels were derived by taking the modelled (anthropogenic) + natural combinations. Therefore, modelled TSP and THC values were multiplied by 1.7 and 5.0 to account for background levels (ORF, 1984). In regions where there are virtually no anthropogenic sources of TSP, ambient levels of 40 ug/m^3 were assumed; this value is representative of a rural site in Southern Ontario (ORF, 1984).

FACTOR GROUPING: ENVIRONMENTAL IMPACT - Air Resources

FACTOR: I2. Existing and Anticipated Air Quality

INDICATOR 4: Estimated Effect on Air Quality - Fugitive Emissions

Site	THC							TSP							
	Existing (ug/m^3)	All Components (ug/m^3)	I^*_A	Incin Only (ug/m^3)	I^*_I	Phys/Chem Only (ug/m^3)	I^*_{PC}	Existing (ug/m^3)	All Components (ug/m^3)	I^*_A	Incin Only (ug/m^3)	I^*_I	Phys/Chem Only (ug/m^3)	I^*_{PC}	Landfill Only (ug/m^3)	I^*_{LF}
LF4N	60	0.6	1.01	0.6	1.01	.002	1.00	40	3.9	1.10	.05	1.00	1.0	1.03	2.8	1.07
PI1N	70	0.6	1.01	0.6	1.01	.002	1.00	40	3.9	1.10	.05	1.00	1.0	1.03	2.8	1.07
PI13N	85	0.6	1.01	0.6	1.01	.002	1.00	40	3.9	1.10	.05	1.00	1.0	1.03	2.8	1.07
LF9C	150	0.3	1.00	0.3	1.00	.001	1.00	40	2.3	1.06	.03	1.00	0.6	1.02	1.7	1.04
LF3C	130	0.3	1.00	0.3	1.00	.001	1.00	40	2.3	1.06	.03	1.00	0.6	1.02	1.7	1.04
LF1E	350	0.3	1.00	0.3	1.00	.001	1.00	80	2.3	1.03	.03	1.00	0.6	1.01	1.7	1.02
PI27E	375	0.3	1.00	0.3	1.00	.001	1.00	94	2.3	1.02	.03	1.00	0.6	1.01	1.7	1.02

Site	Mean Index				Suitability Level	
	I_A	I_I	I_{PC}	I_{LF}	(All Components)	(Phys/Chem Only)
LF4N	1.06	1.01	1.01	1.04	-5.0	-5.0
PI1N	1.06	1.01	1.01	1.04	-5.0	-5.0
PI13N	1.06	1.00	1.01	1.04	-5.0	-5.0
LF9C	1.03	1.00	1.01	1.02	-3.0	-3.0
LF3C	1.03	1.00	1.01	1.02	-3.0	-3.0
LF1E	1.01	1.00	1.00	1.01	-1.0	-1.0
PI27E	1.01	1.00	1.00	1.01	-1.0	-1.0

$*I = \frac{C_n + C_e}{C_e}$ C_e = Existing concentration; C_n = Concentration attributable to facility